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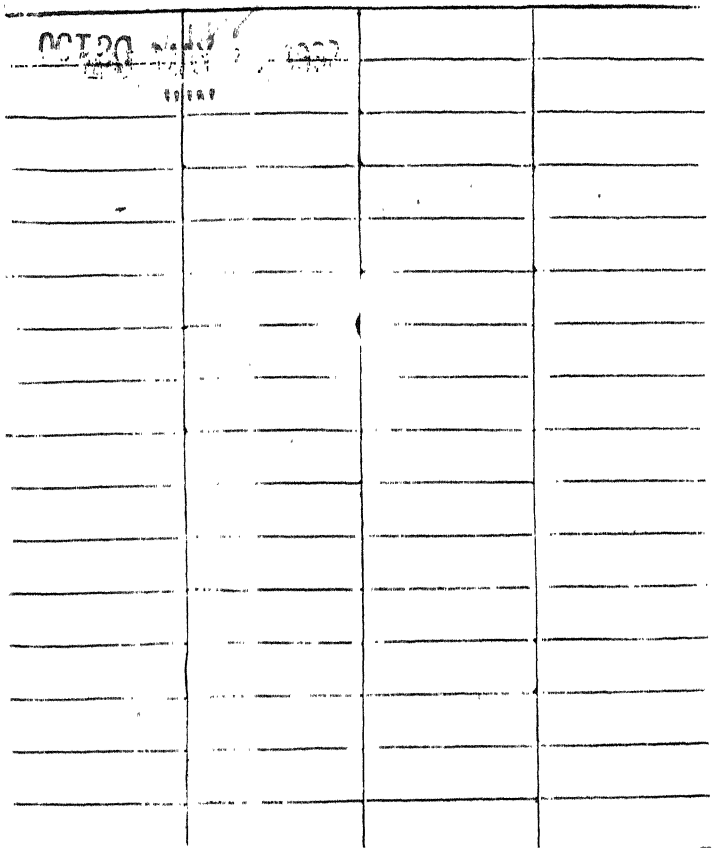

MENTAL GROWTH OF CHILDREN

MENTAL GROWTH OF CHILDREN

IN RELATION TO RATE OF GROWTH IN BODILY DEVELOPMENT

A Report of
The Bureau of Educational Experiments
New York City

BY

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NEW YORK
E. P. DUTTON & COMPANY
681 FIFTH AVENUE

Printed in the United States of America

Printed in the United States of America

AUTHOR'S NOTE

THE psychological work of the Bureau of Educational Experiments was under the direction of Dr. David Mitchell from 1918 to 1920, during which time the Bureau published reports on Nutrition and a Bulletin of Intelligence Tests, and work on the testing of children in public and private schools was begun. From 1920 to 1923, the psychological work of the Bureau was under the direction of the author, who had been assistant psychologist the preceding year.

The investigation reported in this volume was commenced by the author in 1919 and continued under her full direction during the period from 1920 to 1923, and she is responsible for the general plan of the work and for the results as here given.

In the conduct of the investigation the following persons on the staff of the Bureau have assisted directly in the work or have made contributions from the results of their own investigations: Miss Louise Schriefer and Miss Dorothy Seago assisted in making the psychological examinations and in the detailed work of statistical analysis; Miss Veda Elvin made the social investigations; Dr. Edith Lincoln made the physical examinations; Miss Harriet Forbes and Miss Suzanne Garrett made the consecutive measurements of height and weight; Miss Harriet Johnson measured height and weight and recorded activities of the children in the Nursery School.

The investigation would not have been possible without the interest and co-operation of the directors and teachers of the schools in which we were permitted to work. For this co-operation we are especially indebted to Miss Caroline Pratt, of the City and Country School; to Dr. J. L. Carver, Director of the Friends' Seminary; to Miss Anna Gillingham, of the Ethical Culture School; to Principal Louis Marks, of Public School 64; to Principal J. E. Wade, of Public School 95.

For suggestions for the revision of the manuscript I am indebted to Professor Knight Dunlap, of the Johns Hopkins University, and to Mr. Frederick W. Ellis, of the Bureau of Educational Experiments.

BUFORD JOHNSON

BALTIMORE, MD.
May, 1924

FOREWORD

THE Bureau of Educational Experiments was organized some seven years ago for the scientific study of the growth of children. We conceive of growth as something that takes place as a whole, though the various complicated processes that go to make up growth may be singled out for special study: indeed, they have been so singled out by physicians, psychologists, and other specialists engaged in making accurate observations of children. Although various aspects of growth have been thus diligently studied, the results have not, on the whole, been brought into organic relation with each other and the findings remain scattered through a wide range of monographs and articles. As yet science nowhere gives an adequate picture of children as integrated growing organisms.

Consequently, while much help is available for psychologists and clinical workers on particular aspects of the development of children, comparatively little information is to be obtained by teachers and parents, whose main dealings are with children as wholes. A school cannot deal with any portion of a child without questioning what its treatment is doing to the rest of the child. It cannot develop children's bodies without questioning how its method of development will affect the children's social adjustments; it cannot develop children's social adaptability without questioning how its method will affect the children's interests; it cannot cultivate children's interests without questioning how its method of development will affect the children's bodies. In short, a school cannot deal separately with the physical and mental conditions of growth. Schools, and homes as well, must in the very nature of the case, regard children as integrated organisms, not as mere conglomerations of parts. Yet the situation we have to face, when we turn to the literature of growth, is that it is only on parts that we get information that is full or accurate enough to be called scientific.

So it comes about that teachers—those who should be plan-

ning an environment in which children may grow—have taken little account of the isolated studies in growth made by specialists whose interests have been limited to certain narrow aspects of growth; and the specialists in turn have passed by the studies of the interaction of children and environment made by educators. The anomaly is even greater. The specialists with few exceptions have not appeared to think of schools as a field for the study of growth, or even as a place planned for children to grow in.

It was this generally unsatisfactory condition in the organization of knowledge and in the method of obtaining and using information which first started the Bureau on its work. We definitely addressed ourselves to the task of gathering and relating the literature of growth, and to the more arduous task of discovering new facts that will be serviceable in bringing the present information on this important subject into more satisfactory relations. From the beginning we have had on our staff a physician, a psychologist, and a social worker: from time to time we have added a number of other research workers. And from the beginning we have studied children within a school; for it has been our constant aim to learn how children grow both physically and mentally, and how physical growth is related to mental growth. The latter term we use in the broad sense which includes social adjustments along with the technique of learning and the accumulation of knowledge.

It has, furthermore, been the constant belief of the Bureau that its best opportunity for this study of growth lay in working with experimenters in education who were engaged, not in the old-school task of finding methods of forcing growth along strictly prescribed lines, but in the new-school task of finding out how children do grow and of planning a school environment which will give a maximum amount of aid to the children themselves. For three years the Bureau carried on experiments in public schools (P. S. 64 and P. S. 95 in New York City), these experiments centering primarily around the problem of nutrition and the relation of nutrition to the rate of physical and mental growth.[1] But while this work gave us some valuable information, we did not find ourselves in a position to influence the school situation in any vital way; nor could we judge how far our findings were conditioned by the school system which

[1] Hunt, Lincoln, Johnson, *Health Education and the Nutrition Class.*

dominated the children studied. Our work remained detached from the school situation, and we withdrew definitely to a field where we had found the school conditions more favorable to children's growth, and where the experimental attitude toward the school procedure gained us a hearing and gave us a share in shaping the school program, especially in the matter of physical fitness through preventive work.

In this private school opportunity we feel that we have been particularly fortunate; it is in this school and in our own Nursery School that the major part of our work has been done. Three years before the Bureau was organized, Miss Caroline Pratt, who later became one of the original members of the Bureau, had started a small experimental school for young children. This school, originally called the Play School and now called the City and Country School, Miss Pratt offered to the Bureau as a laboratory. Our physician, psychologist, and social worker have all been able to make direct records of all the children each year, and also to make special studies of selected groups from time to time. For example, we offered to the School the services of a special research worker in record keeping, so that we were able to contribute to the difficult technical problem of securing an adequate record of the progress of the children as individuals and in groups—a record which was valuable for our own study as well as for the School.[1] We made a study of fatigue and blood sugar content with a group of children of high fatigability.[2] We extended the study of muscle co-ordination by pictorial records of the children's activities through the use of moving pictures. All the records made by the teachers [3] and the children's own productions, such as drawings and stories, have been open for study by our staff. When we began our work the age range of the children was from four to seven years. There are now in the City and Country School 140 children ranging in age from three to twelve years.

Finding that we needed to extend our observations to still younger children the Bureau in 1919 started a Nursery School, under its own auspices, for children from sixteen months to three years. The number of children in the Nursery School is

[1] Bulletin XII, Marot, Mary S. *School Records.*

[2] Reprint, Johnson, Buford J., Ph.D. *Fatigue Effects as Measured by Sugar Content of Blood.*

[3] See *Experimental Practice in the City and Country School,* edited by Caroline Pratt with a *Record of Group VII* by Lula E. Wright. See also *Record of Group VI* by Leila V. Stott and other records in the Bureau Library.

limited to eight to ten. They go from the Nursery School to the City and Country School, so that in some cases it will be possible for us to accumulate records of individual children beginning with sixteen months and carried through to thirteen years. The Nursery School was organized as an experiment both in education and research. Through it we have gained an adequate control of the conditions favorable for experiment during the hours from nine to four, five days in the week. Very full records have been kept, including full-day records of individual children taken at regular intervals, and these are supplemented by the records of the physician, psychologist, and social worker.[1]

Such, in brief, is the Bureau set-up and general method of attack on the development of growth in children. We are constantly asking ourselves how far our methods have brought us along our difficult road. In particular, it is pertinent to ask how far the series of studies presented in this volume will further our aims. Most of our publications so far have been in the nature of special studies not yet fitting into a general picture.[2]

We now have materials in the records of our research staff which should help us to take some forward steps in constructing a general picture, provided we can bring out the relationships that exist among the different bodies of data. Our first step towards relating our different investigations is to set in order the materials which best lend themselves to the effort at correlation because of their more precise statistical nature. In the collection and treatment of this part of our material the psychologist has had not the lightest of the tasks. This volume presents our first considerable contribution from this source.

When we began our work, norms of mental tests for very young children had not been established; upon babies there had been comparatively few accurate observations. Even for older children the norms that had been established were often of little or doubtful value for our purposes. The children who had been used in establishing these norms had for the most part been the subjects of formal school training. The tests often tested the system of training, not the children. The pictures of growth obtained from the results of this testing of children within a

[1] Johnson, Harriet M., "A Nursery School Experiment" (Bulletin XI).

[2] Johnson, B. J., Schriefer, Louise, *A Comparison of Mental Age Scores Obtained by Performance Tests and the Stanford Revision of the Binet Scale.* (Reprint.)

Johnson, B. J., *Fatigue Effects as Measured by Sugar Content of Blood.* (Reprint.)

rigid school system were consequently of growth under conditions that hamper growth.[1]

The studies that appear in this monograph are on records of the Bureau, gathered under very different conditions, over a space of five years. They tap only a small portion of our total volume of records. But their formulation represents an important and necessary stage in our progress, since they clearly demonstrate that the rate of growth of an individual is of relatively greater importance than the particular stage of development at which our tests locate him. The establishing of this fact and the progress made by our psychologist in developing a method for studying rate of mental and physical growth seem to hold considerable promise for our further study, particularly of the growth of very young children. In view of our findings and of the pressing interest in the exact details of the growth process we feel that the time has come for publication of such material as has been put in organized form.

This volume is presented with the hope that it may both aid and stimulate the constantly growing interest in the comprehensive study of the growth of children.

LUCY SPRAGUE MITCHELL
Chairman of the Bureau of Educational Experiments
144 West 13th Street, New York City

[1] In the course of its preliminary work the Bureau prepared a Bibliography of tests (Bulletin VI—"Psychological Tests") and issued a translation of Schiötz: *The Development of Children Between the Ages of Two and Six Years.*

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CHAPTER I

PROBLEM AND METHOD

THE primary purpose of this investigation was the accumulation of scientific data concerning the mental growth of children and the relation of the rate of mental growth to the rate of growth in other phases of bodily development. Data obtained by scientific methods concerning the growth of children have been too few or too limited in scope for the actual determination of the rate of growth. Systematic study of the various phases of growth in the same children for a number of years has not been made. The ideal study would begin with the child at birth, if not earlier, and follow the successive stages of development of this same child until he reached maturity. Without this possibility it is desirable to begin with the child at as early a stage of development as is possible.

The City and Country School, affiliated with the Bureau of Educational Experiments, enrolls children from the age of three upward; the Nursery School of the Bureau was established for the study of children below three. The children in these schools are the nucleus for the study reported here.

A co-operative program was planned for the collection of data concerning the growth of children which involved records for the same children by teacher, social investigator, physician, and psychologist. The observations of the teachers in these schools recorded in note-books together with the products of the children in the schoolroom such as stories, drawings, paintings, objects modeled in clay or constructed in wood, have been available for our study. Photographic representations of block constructions and of various activities of the children have been made by the teachers, sometimes at our request. Direct observation of the children in the varied activities of the day, includ-

ing performance in dancing, music, dramatics, and in yard play, has been possible.

The records of the school physician have included annual measurements of anatomical and physiological changes, in addition to more detailed investigations of special phases of physical growth. We have used the records of blood pressure, pulse rate, reflexes, weight, and height for the relating of mental to physical growth.

Personal data as to stock, nationality, economic status, and developmental history have been obtained in the social investigations. These data have not only been used in describing the sample of children studied, but throughout the period of study they have contributed toward specific study of certain phases of individual development.

The psychological examinations for which data are reported were made by three examiners.[1] The procedure was standardized and there is no indication in the records that re-examinations by a different examiner, as in this case when both examiners were well known to the children, materially influence the results.

Selections of Subjects

The children enrolled in the two schools were not rigorously selected upon any specific basis. During the past three years preliminary examinations of the children three and above have included the Stanford Revision of the Binet-Simon Scale and occasionally other specific tests. Since the school was not experimenting upon mentally retarded children those children having an intelligence quotient below ninety were not recommended unless specific conditioning factors made the prognosis of future development favorable. There are a few cases of lower quotients at the first testing. A few children of specific neuromuscular defects and requiring special care were rejected because the school does not attempt to meet the needs of such special cases. The psychological examinations contributed in no other way to the selection of children which was partly determined by the plan of the school as mentioned above. That

[1] The consecutive examinations of the same children were made by Louise Schriefer and the writer. Dorothy Seago examined the kindergarten children from other schools for supplementation of data for these early years.

the distribution of intelligence quotients for the group is skewed so much toward the upper end is due to chance and to the selection of the school by parents or children.

The enrollment of this school has increased from 38 for the school year 1918–19 to 142 during the past year, 1922–23. The number of each age and of each sex has varied from year to year. The policy of the school does not permit of the segregation into groups for schoolroom activities of more than twelve or fifteen at any age, hence the number at a given age and of a given sex is relatively small from year to year.

Despite the hope that stability of patronage might be maintained, the mortality has been great. It is usually expected that a large number will drop out and New York City has probably a greater fluctuation in population than other large cities. We have consecutive records for 12 children over a period of five years; 31 children for four years; 55 children for three years; and 70 children for two years, while the total number of individuals examined during that time was 272 including 151 boys and 121 girls. In addition to this group, observations have been made upon 25 children in the Nursery School, 10 of whom have entered the City and Country School.

The nationality for 145 children in school during 1920–21 and 1921–22 is representative. Table I shows that only eight of these were born outside of the United States, and 83 per cent of the parents whose birthplaces are stated were also born in the United States and in very few cases is the native tongue other than English.

The occupations and professions of the parents are widely distributed. Eleven mothers and 21 fathers are artists (painters or sculptors); 8 mothers and 6 fathers are teachers; 5 mothers and 4 fathers are clerical executives and the same number of each are engaged as clerical aids; 4 mothers and 3 fathers are writers. The other 6 mothers of the 39 who have positions or professions are distributed one each as follows: actress, handicraftman, editor, pianist, librarian, advertising agent. Nine fathers are lawyers; 4 are advertising agents; restaurant proprietors and business managers number 3 each; physicians, real estate agents, secretaries, bankers, and brokers number 2 each. The other 15 fathers of the 84 for whom data were available were distributed 1 each to the following occupations: architect, accountant, butcher, chemist, chauffeur, composer,

Table I

BIRTHPLACE OF CHILDREN AND PARENTS

	Child	Father	Mother
United States	137	119	119
Canada	3	.....	4
England	1	6	4
Scotland	.....	2	
Ireland	.....	.....	1
France	1		
Italy	.....	4	2
Germany	.....	.....	3
Russia	.....	8	5
Austria	.....	.....	2
Wales	.....	1	
Holland	.....	1	
Hungary	.....	1	
Roumania	.....	.....	1
Syria	1		
Cuba	1		
Central America	1	.....	1
West Indies	.....	.....	1
Norway	.....	1	
Unknown	.....	2	2

dentist, electrician, janitor, merchant, photographer, reporter statistician, minister, and truck driver.

Adopted children among this group of 145 children number 9. There are 56 children who are the only children each of whom is the only child in the family; 57 children are each one of two children in a family. The remaining 32 are in families where children number three or four.

At the beginning of our study there were so few data from psychological measurements for children below six years of age that we early felt the need of more rapid accumulation of data for those ages. Through the co-operation of three private schools in New York City the children in the Kindergarten sections were given a brief series of tests for establishing standards for these ages. Results from fifty children between the ages of four and six inclusive were obtained. These are only included in the studies of the performances in a given test at a given age for the purpose of determining a more representative value as an age score.

In addition to these groups eighty-eight children in a public

school in an Italian section of New York City were examined. One group was a kindergarten class conducted under the supervision of Mrs. Marietta Johnson as a school experiment and the other children were of the same ages but formed the regular first grade of the school. Two hundred and four children, predominantly Russian and Austrian Hebrews from a public school of New York City, were also examined in a special investigation. Results from these examinations are also included in the determination of age scores, but in no case were there retests of these children and the year to year records were all obtained from the two school groups described which form the basic groups for the study.

Selection of Tests

A series of tests that would best measure the various phases of mental development in the young child was the desideratum. Other than the revisions of the Binet-Simon Scale, there were in 1918 practically no standardized tests for children below five, and few studies reported results for children between the ages of five and eight. Since the children under observation in the beginning were all below the age of nine it was essential to make preliminary investigations upon methods and technique for psychological study of young children. A beginning was made by adaptations of methods used by other investigators upon older children. The tests for which data are reported, together with the discussion which follows of tests that were discontinued or else have not yet been applied to a sufficient number of children for statistical analysis of the data, indicate the scope of the investigation. The final selection of tests for continued study has been somewhat determined by the practical requirements, but the primary influence has been the aim to include tests that will give a fairly complete picture of mental growth in its relation to certain phases of bodily development.

All tests that required knowledge of reading, writing, and names of digits had to be eliminated. The children are taught reading and writing at a later stage than in the usual school, hence speed and accuracy in these processes could not be assumed to be comparable with prevailing norms even at the ages of nine and ten. We were not limited to the use of tests easy and brief in administration and consisting primarily of

simple materials readily adjusted. Laboratory space was provided in rooms adjacent to the school and laboratory methods were employed. The laboratory was not so formidable in appearance compared with the schoolrooms as to make for a strangeness that could not be easily overcome and the apparatus was an attraction to the children rather than otherwise. We shall not enter here into a discussion of methods of psychological study that either have not yet progressed to the point of application or that have not been applied to a sufficiently large group to justify interpretation. All of the observations of the child have been fruitful from a diagnostic viewpoint. As accurate descriptive accounts of behavior in the laboratory as could be given in retrospect have formed a part of the case histories.

Among the tests discontinued were card-sorting, simple form of tapping, sorting of colored sticks, substitution, picture preference, walking board, color-naming, and free association. In the card-sorting test it was necessary to vary the usual procedure having only twenty-four cards sorted at a time as the small child could not easily grasp a larger pack. At the age of three, the children of our group were not equally familiar with the names of the colors. We believed that forms of hand-eye co-ordination not involving color discrimination would be more suitable for the retesting program. The color-naming and sorting of colored sticks were also omitted for the same reason. They have been useful in individual diagnosis and if a preliminary training in color-naming were given would doubtless form good tests for a systematic study of mental development. The sticks are easier for the young child to handle than cards, but seem to offer greater incentive for play. They also require a longer time. The simple form of tapping was used for two years and was discontinued only for lack of time. A kymographic record seemed too valuable to omit. The alternate plate form of tapping gave a measure of rate of movement and the more complicated activity gave additional data that we desired. It was not practical to continue with both forms. Substitution tests of various forms have been used, but the forms have differed for age groups. The standardized forms involving letters or numbers could not be used for comparative ratings of the children under eight, as naming or writing of such symbols was not a part of their school curriculum. The Woodworth-Wells Substitution test and the Memory Span for Digits

as given by Woolley have been used with the older children. The Substitution test is included in the Performance scale rating. The cancellation of other symbols than letters or digits and the substitution of one such symbol for another have been used with the young children. The number of cases for each form is small as yet and we are not including the data in this study.

The walking board performance which we described in a previous study (9)[2] offered difficulty as to control and scoring. The rate of walking, the length of steps, and the position of body are factors for which better control is needed. Improved apparatus will doubtless lead to an improved method of scoring. We believe some such measure of general bodily control is needed and we have only temporarily discontinued this form, hoping to refine the procedure.

The Stanford-Revision of the Binet-Simon Scale was used throughout, and selected tests from the Pintner and Paterson Scale of Performance tests were also given from the beginning. These graded series were supplemented by Witmer Cylinder Formboard, Dearborn Formboard No. I C, Healy Pictorial Completion II, the Rossolimo graded series of dissected pictures, association and rote memory tests. The annual measurements also included strength of grip, steadiness of motor control, rate and accuracy of simple and complex muscular reactions. For some of these measurements new methods and materials were devised. The examinations were made as nearly a year apart as it was practically possible to arrange it. Absences from school and the time required for individual examination militated against absolute regularity in schedule.

Specific studies were made at irregular intervals. Certain tests of perceptual and associational processes that are reported in Chapter VI belong to this group. The Ishihara tests of color blindness were used in 1920–21, and the four children whose reactions varied widely from the group were given the Holmgren test. Only one, a boy of eight, showed color weakness in this test.

[2] Figures in parentheses appearing throughout the text refer to List of References on p. 153.

Testing Procedure

Description of apparatus and procedure is given in the portion dealing with the specific test for which the results are reported. The tests were given to the children individually in the laboratory unless it is otherwise stated, and under standard conditions. A feeling of ease with the examiner and an interest in the performance on the part of the child was always secured in so far as general observation gave any indications. It was frequently necessary with the very young children for the examiner to spend hours at various times in the schoolroom becoming acquainted with the child preparatory to asking him to go to "her room and play." In a few cases attractive objects were taken into the schoolroom as a lure and proved successful. Once a child was in the room where there were various objects that could be used in social adaptation, there was no difficulty in securing his co-operation. An exception occurred in the case of two babies with whom we were undertaking a study of discrimination reactions. The re-enforcement in the form of adult associates of the nursery was unavailing for the control required. They were not two years of age, however, and sufficient acquaintance with the examiner had not been developed.

Care was taken that the tests be given under standard conditions and that any variation in procedure or chance interference be recorded.

The scores were written upon the original blanks shortly after testing and in the statistical treatment of data all scores and computations have been rechecked. The statistical analysis of growth as measured by changes in performance from year to year has been complicated by the factors of age and sex and practice. We cannot make valid statements as to growth in steadiness of motor control, for example, unless we consider separately the children who had the first test at different ages. Each group used as a unit should consist of one sex, of one age, and of the same number of practice periods. The small number in each group reduced the unit group to one too small for statistical analysis when these factors were considered. As an illustration, there may be one hundred children, fifty of each sex who were tested when six years of age. The age at which the first test was given will range from three to six. If we assume that twenty-five were first tested at each of these

four ages, we have our unit group reduced to twelve boys and thirteen girls, we will say. In many of our groups the division by sex lacks this uniformity. In some tests when the numbers did not warrant more definite statistical analysis we have reported them, hoping that the data might be valuable for addition to other data that may be accumulated later.

The frequency tables for age differences in scores have not been based upon the elimination of sex and practice factors. These factors have been studied when the number of cases justified it. Year and half-year were chosen as the dividing points for chronological age in many of the tests. This division seems desirable for continued study of the very young child and we have sacrificed numbers at a given age to this consideration. The numbers reported for a given age include all children for whom we had records in that test at that age. Since the greater number of children entered the school at five the values from five to nine include a large number of the same children, and the values given as age scores would seem more representative than scores obtained from an entirely different group. As an example, it will be noted that of the 48 children tested with the Rossolimo pictures at seven, 41 of them had been included in the six-year group. The correlation method has been used for the elimination of the effect of varying chronological ages and for the study of sex differences as well as for the determination of relationship between the different forms of measurements. The coefficients of correlation were derived according to Toops'[3] formula, which is equivalent to the Pearson product-moment formula. The partial correlation coefficient is also used to express the relation between two variables for constant values of a third (or more) value. In a few cases the distributions suggested non-linearity in regression and Blakeman's criterion was used. The correlation ratio was computed when non-linear regression was shown.

[3] This method is described by Toops in the following article: *Eliminating the pitfalls in solving correlation: a printed correlation form.* J. Exper. Psychol., 1921, iv, 434–446.

*

CHAPTER II

ANATOMICAL AND PHYSIOLOGICAL GROWTH

THAT the mental growth of the child is conditioned by the anatomical and physiological characteristics of the organism is widely accepted. A clear understanding of the effect of differences or changes in structural development and in physiological processes upon the mental reactions of the child awaits the accumulation of exact data concerning individual differences in these phases of growth.

The difficulty of determining norms and normal variation, even in a single characteristic such as weight, has been recognized by many investigators. Stalnaker (22) gives a summary of studies clearly illustrating this difficulty. Data showing the growth of the same individuals throughout a period of years are essential for the understanding of the relation between the various phases of growth of the organism.

The accumulation of comparable data obtained at approximately uniform intervals from a relatively small group is a task beset by many obstacles. The difficulties can be overcome only by exact methods in measurements, and by control of conditions, with complete co-operation of all engaged in the research. An institution planned for this purpose and regulated in accordance with the demands of the problem is the ideal situation. The situation as described in our introductory statements offered a better opportunity for collecting such data than has been available for previous studies of these factors. Certain conditioning factors, such as interval between measurements, have not always been as rigidly controlled as we had planned. Not all measurements have been made at as frequent intervals as would be desirable. The children were not under observation during the summer months and the lengthened interval between measurements prevented accurate determination of certain phases of growth. The physiological processes that are so markedly affected by diet, exercise, and emotional stimulation, are not

assumed to be directly comparable for all individuals, though control of these conditions was attempted as far as was practicable. The number of cases and the repeated measurements from year to year tend to reduce such errors. The blood pressure and pulse rate readings are used for the determination of the relation between the various phases of growth. Analytical studies of these data are not attempted here but are being made by Dr. Edith Lincoln, of the Bureau staff.

Height and Weight

Many factors conditioning these measurements have been previously discussed by other writers, and a summary of these discussions is given by Baldwin (1). The time of day, the period within which food or drink have been taken or waste products eliminated, together with exactness in calibration of scales and in method of measuring, condition the results to such an extent that a young child may be variously classified unless great care is exercised in the control of test conditions. These factors received specific consideration and the procedure followed in the systematic study of growth was progressively modified in accordance with the findings of the special studies. The very young child in the nursery school was measured without clothing each week. Groups of children in the upper classes were measured without clothes at intervals of two months for certain periods of time. Some children specially selected for observation were measured more frequently for varying periods. The measurements with clothes (shoes and jackets removed) were made at more frequent intervals. The clothing that remained was not a constant for individuals of same age or size nor for same individuals at different seasons. The curves of growth for the same individual under the two conditions show the same trend, except for a brief period in winter, when the clothing causes a widening of the distance between the two. The allowance to be made for clothes as established for the Wood-Baldwin table seems a fair average measure but is not correct in many individual cases. When large numbers are to be considered, such errors may have little effect upon the statistical measures obtained. If an individual child is to be classified by some arbitrary standard as to percentage underweight for age, sex, and height, more careful measurements should be made.

GROWTH IN HEIGHT AND WEIGHT OF CHILDREN IN NURSERY SCHOOL

The weekly measurements of height and weight of the individual children in the Nursery School group were averaged and

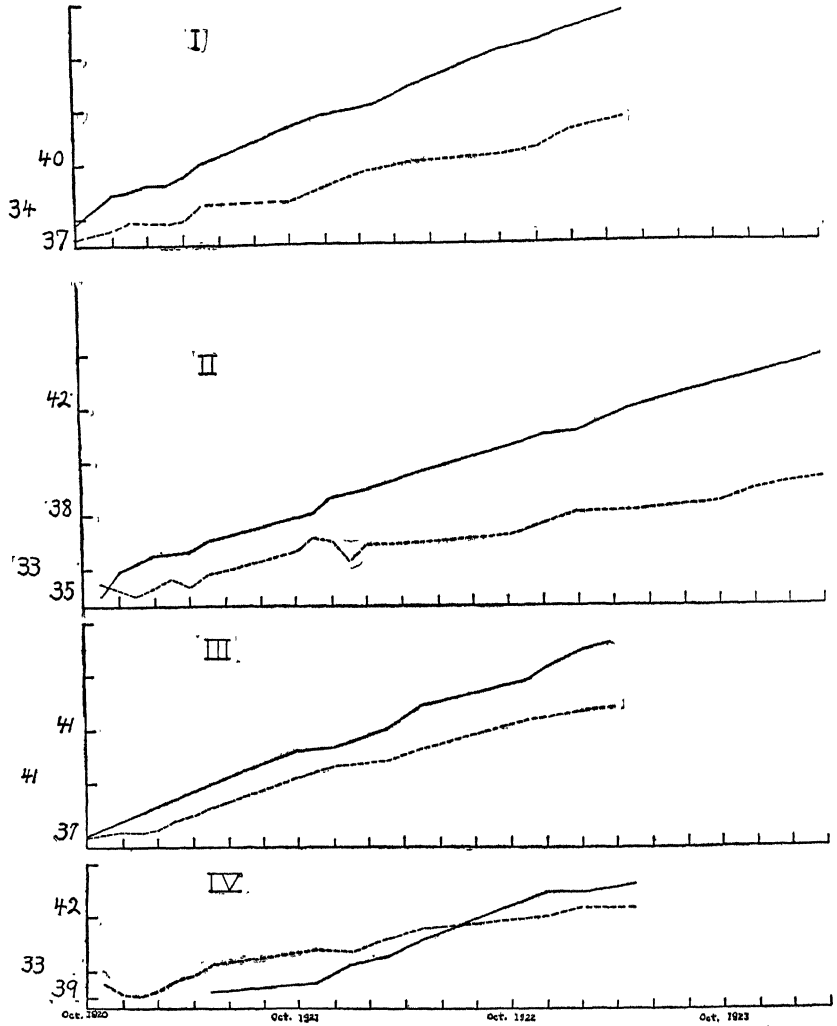

FIG. 1.—Individual growth curves for weight and height of two boys and two girls. The continuous line shows height; the dotted line, weight. I and II are girls, III and IV are boys.

this average was used in the tabulation for intervals of one month, given in Table II.

Among the children a few months apart in chronological age,

a wide variation in rate of growth is shown. The fluctuations from month to month are irregular as to absolute value and as to direction of changes. The growth curves of certain of these children shown in Figure 1 are contrasted with the curve drawn from norms given for these ages. The norms used are those given in Physical Growth of Children, by Baldwin (1).

It is evident that growth in height and weight during the first years of a child's life is dependent not only upon sex and the general environmental influences such as diet and daily régime, but upon other factors as well.

Until we have exact data for a sufficient number of cases of each type of build and rate of growth, the growth to be expected of a given child can not be determined.

Baldwin (1) suggested significant and unexplained fluctuations at five and six. The growth curves (Figure 2) plotted from the averages we obtained at each age and for norms established by Baldwin do show greater fluctuations at ages five and one-half to nine and one-half than in earlier years. However, individual children show fluctuations at two and three years of age little different than those shown at ages five and six.

The differences in rate of growth are of importance for an understanding of the abilities of the child in muscular co-ordination. The relation between the total growth and that of portions of the body should receive special study during the early years. This is illustrated by the differences in anatomical traits and in development of muscular control for two boys, both born in the same month of the same year and entering Nursery School within two months of each other.

Subject E: Boy; weight at birth, 7½ pounds; age at which walked, 18 months. Parents of English and German ancestry, American for several generations. Height of father, 5 ft. 10 in. Weight, 165 pounds. Height of mother, 5 ft. 6 in. Weight 120 pounds.

Entered Nursery School, October 29, 1920. Age, 1 year 4 mos. 5 days. Weight, 27.25 pounds; reflexes: knee-jerk—active, ankle—tried for but not obtained, biceps—present, triceps—present. Babinski—tried for but not obtained.

Our record of observations made in the Nursery School in April, 1921, include the following statements: "E does not seem as stable as the other children. When he walks or runs and tries to stop he seems to have difficulty in maintaining equilibrium.

Table

WEIGHT AND

Individuals	Birth Month	Age at 1st Weight		October	November	December	January	February	March	April	May	October	November	December	January	February
Boys																
1	June	1.4	Wt.	....	27.8	28.3	28.3	28.8	28.8	29.5	....	30.8	31.5	32.3	31.3	32.5
			Ht.	....	....	....	....	....	....	....	....	36.8	....	....	....	37.5
2	June	1.6	Wt.	....	....	25.0	24.5	24.8	25.5	26.5	26.5	30.8	29.5	29.3	31.0	31.3
			Ht.	....	....	....	....	....	....	....	....	36.5	....	....	....	37.5
3	February	1.8	Wt.	26.3	25.8	26.5	26.8	26.3	26.0	26.8	28.0	29.0	29.5	30.3	30.0	31.0
			Ht.	32.5	....	....	....	....	33.8	....	....	....	35.5	36.0	36.0	36.5
4	February	1.9	Wt.	....	....	27.3	28.3	....	29.0	29.8	29.5	....	31.3	32.0	32.0	34.3
			Ht.	....	....	33.0	....	....	33.5	....	34.5	....	37.5			
5	January	1.9	Wt.	....	29.5	29.8	....	....	....	29.0	29.0	....	32.3	33.0		
			Ht.	33.5	....	....	....	....	....	....	....	....	37.8			
6	December	1.8	Wt.	33.0	33.5	33.5	33.3	33.5	33.3	34.0	34.3					
			Ht.	....	34.5	35.5	35.8	35.8	....	36.0						
7	November	2.2	Wt.	....	....	29.0	....	....	....	....	....	....	34.3	34.5	33.8	33.5
			Ht.	....	....	34.5	....	....	....	....	....	....	37.3	37.3	38.0	38.8
8	July	2.3	Wt.	30.0	29.8	30.5	31.5	31.3	32.0	32.3	33.3					
			Ht.	36.8	....	....	....	37.5	37.5	....	38.5					
9	July	2.4	Wt.	....	31.5	30.5	30.3	30.8	32.0	32.5	33.8	....	35.5	....	35.2	
			Ht.	....	....	....	....	....	....	....	39.3	....	39.6	....	40.3	
10	April	2.6	Wt.	35.0	35.3	35.5	35.5	35.8	37.0	37.5	38.3	41.6	....	42.9		
			Ht.	37.0	....	....	....	....	....	....	39.0	40.2	....	40.3		
Girls																
1	December	1.3	Wt.	....	....	....	....	23.5	23.8	25.0	25.0	25.3	25.8	28.0	26.8	27.5
			Ht.	....	....	....	....	....	....	....	....	32.0				
2	June	1.5	Wt.	....	26.3	26.8	27.0	27.0	26.3	26.3	28.3					
			Ht.	....	....	....	....	....	34.0	36.2	36.2					
3	October	1.5	Wt.	....	....	....	....	....	....	21.8	23.0	26.0	25.8	26.5	27.3	27.3
			Ht.	....	....	....	....	....	....	....	....	32.3	32.5	32.8	33.0	33.5
4	February	1.8	Wt.	22.5	23.0	24.8	24.0	24.0	25.8	26.3	26.5					
			Ht.	32.8	....	....	....	....	34.0	34.8						
5	January	1.9	Wt.	23.8	24.5	....	24.5	24.8	24.3	25.0	25.0					
			Ht.	....	....	33.5	....	34.0	34.3	34.8	34.8					
6	February	1.8	Wt.	....	....	25.5	26.0	25.8	26.5	27.3	26.8	28.8	29.3	29.5	29.0	
			Ht.	....	....	33.2	33.5	34.1	34.2	34.5	34.9					
7	December	1.9	Wt.	....	27.8	28.5	27.8	28.8	29.3							
			Ht.	....	35.3	....	35.3									
8	February	2.9	Wt.	....	31.3	....	30.0	30.8	31.8	31.0	32.3	34.8	36.3	36.0	33.8	35.5
			Ht.	....	35.0	35.9	....	36.5	....	36.6	37.0	37.8	38.0	38.6	....	38.8
9	February	2.9	Wt.	31.8	....	32.8	33.5	33.5	33.5	33.8	35.3	35.8	....	37.4	....	39.0
			Ht.	37.8	....	38.8	39	39.3	39.3	39.5	40.0	41.3	....	41.7	....	42.1

If he is standing for some time he has a tendency to step back on his heels and then forward as though trying to balance himself. Is it that the head and upper part of the body are slightly larger and longer than similar parts of the usual child of his age as compared with the other parts of the body? We immediately made some measures of these variations in this particular child and also studied the photograph on cross-line background.

II

HEIGHT. INFANTS

March	April	May	October	November	December	January	February	March	April	May	October	November	December	January	February	March	April	May
31.5	32.8	....	....	33.7	34.8	....	....	35.1	....	36.5								
.....	37.5	....	....	39.5	39.5	....	....	40.1	....	40.4								
31.3	31.0	32.0	33.1	....	....	34.5	....	....	....	38.0								
37.5	.....	....	39.3	....	....	39.8	....	....	....	40.5								
31.5	31.8																	
37.0																		
35.8	35.3	35.3	35.8	....	38.4	....	....	40.5	....	40.2	43.2	....	....	43.8	....	44.6	....	44.7
.....	38.5	38.5	40.0	....	39.9	....	....	41.1	....	41.6	43.4	....	....	44.3	....	44.3	....	45.2
.....	.....	....	....	....	37.3	36.7	38.5	....	38.8									
.....	.....	....	....	....	40.0	40.2	40.5	....	41.0									
36.7	.....	37.8	....	....	39.2	....	40.1	....	....	40.1								
40.6	.....	41.2	....	....	43.0	....	43.0	....	....	43.3								
43.4	.....	45.0	....	48.1	48.4	....	49.0	....	49.3									
41.0	.....	41.9	....	42.8	43.3	....	43.9	....	44.2									
27.3	26.0	27.8	29.8	30.0	31.0	30.0	30.5	31.0	30.8	31.3								
33.3	.....	34.0	35.5	35.5	35.5	35.8	36.0	36.5	36.5									
.....	.....	35.8	36.4	....	37.7	....	39.0	....	....	39.1	40.0	....	41.3	....	42.2	....	42.7	
.....	.....	39.5	40.4	....	40.8	....	41.0	....	....	41.8	42.7	....	43.1	....	43.4	....	43.7	
.....	.....	40.1	40.9	....	41.5	....	43.3	....	....	44.8								
.....	.....	42.8	44.1	....	44.4	....	44.9	....	....	45.5								

These measurements showed him to be of the same proportions as given for a child two months old."[3]

[3] The measurements for the proportionate parts of the body as illustrated in Figure 3 are:

Top of forehead to tip of chin, for E:	14.2 mm.	for R:	12.2 mm.
Top of forehead to navel	35		31.7
Top of forehead to crotch	44		41.2
Navel to base line	37		38.3
Crotch to base line	27.7		28.8
Neck line to tip of hand	31		33.2

When we trace E's activities during the six months from the time of entrance into the Nursery School at 16 months of age, until May when he was 22 months old, we note a decided lack in

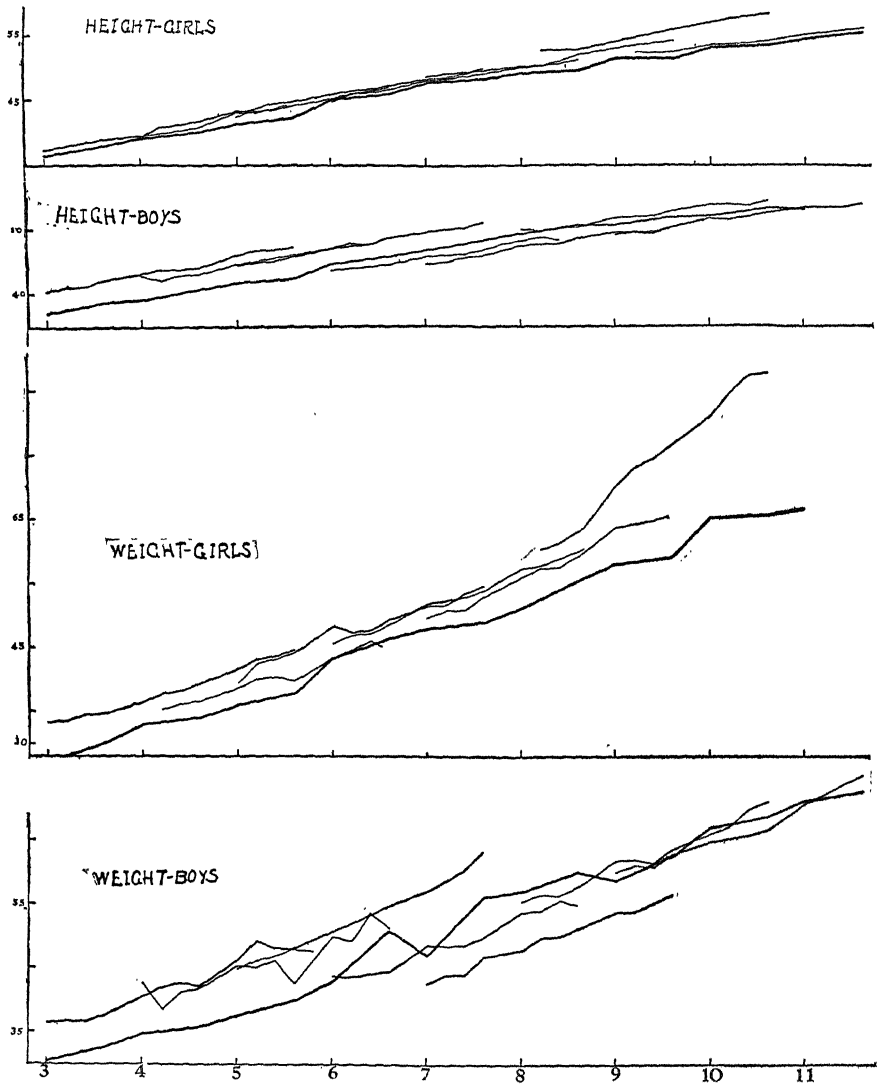

FIG. 2.—Growth curves in height and weight for different age groups. The heavy black line shows Baldwin's norms for these ages. The lighter lines show successive measures for children grouped according to the chronological age at time of first measurements.

muscular control as compared with some of the other children of the same age and under practically the same school environment. The following excerpts from the Nursery records illustrate these differences:

Nov., 1920.—Shows interest in feeding himself, but still shows lack of muscular control. We frequently allow experimentation with a few spoonfuls which are inserted into his mouth upside down. He does not close his mouth after taking a sip of milk from a cup and so we are still spooning his liquids. Has not noticed blocks yet. Slide and steps predominating interests—climbs, walks alone. Outdoor activities—creeping, climbing, walking a few steps.

Dec., 1920.—Has occasionally used spoon himself for a teaspoon or so and feeds self dessert fairly well. Is learning not to put spoon in mouth on edge. Has not learned to drink from cup. Still holds mouth open.

Feb., 1921.—Climbed up on to the end of the slide; crept up on feet and hands until he reached the packing box, then pulled himself across.

March, 1921.—Still gets stalled on slide. Three times one afternoon he pulled one foot over as he sat and was unable to swing the other around. Occasionally he happens to get a push and once or twice has gone down on his stomach.

E was in the Nursery School the following year also, and records made in January and in April of that school year, when all his activities were recorded for a period of two to three hours, show the following development in anatomical traits and in motor control.

Subject E: Age 2 years 6 months. Weight, 32.5 pounds. Height, 37.5 inches. Reflexes: knee-jerk, ankle, biceps, and triceps—just present; Babinski—both right and left.

Observed, 9:06–11:55 A.M.

Activities: Individual play interests: jouncing board, 17 minutes; slide, 4 minutes; hammer and nails, 12 minutes. In box, clearing away stones, piling blocks, and climbing on a board at side, 29 minutes; pushing wheelbarrow a few seconds; frequent vocalization in singing quality and use of syllables.

Motor co-ordination: Legs are not steady; crawled up steps, using one foot and one hand at a time; walked up steps of slide, holding on to railings; climbed on jouncing board and skylight; could not stand erect on a small base; fell over when stooping to pick up something; opened door; held cup in one hand; pounded on rock with hammer; put a nail into a hole already started and hit the nail a series of 25 blows, holding hammer near the head and raising it approximately one or two inches at each stroke.

Speech: Large number of imperfect sentences, with subject omitted, incorrect form of verb, participial form of verb, omission of infinitive, or substitution of name for pronouns I or you; several perfect sentences, as "That's a beautiful pin, isn't it?"; few single words; frequent vocalization. The total number of words used was 414, of which 118 were different words. Relating these numbers to the total time of observation, the number of words used per minute is 2.45; the number of different words per minute is 0.69. The proportion of different parts of speech was as follows:

	Nouns	Verbs	Adj.	Adv.	Pro.	Intj.	Conj.	Prep.	Total
Total	72	130	36	72	75	3	1	25	414
Dif.	33	38	15	15	10	2	1	4	118
Per cent	17.4	31.4	8.7	17.4	18.1	.7	.3	6.0	100

The measurements and observations for Subject E made two months later were as follows:

Subject E: Age 2 years 9 months. Weight, 32.75 pounds. Height, 37.5 inchès.

Observed, 9:26–11:33 A.M.

Activities: Individual play interests: most activity is initiated by himself, and imitation does not play a big part in his choice of play. Went up the steps of slide and slid down three times; pulled a string of colored blocks, 3 minutes; played with ball, 4 minutes; looked out of window at steam shovel, fingering curtain rods, 6 minutes; manipulated plastercine, tussling with another child for pieces of it, showing pieces to adults, for periods of 17, 9, and 30 minutes; climbed upon table and over to slide, 6 minutes; arranged dominoes in a line, spots up, 10 minutes; in block chest, standing blocks up against end, 8 minutes.

Motor control: Opened doors, walked down steps of slide frontwards, one foot at a time; stumbled when walking up slide and over small blocks on floor; fingered plastercine with thumb and forefinger.

Speech: Larger proportion of complete sentences; total of words used was 279, different words used, 115. The number of words used per minute is 2.2; the different words used per minute is 0.91. Proportion of parts of speech follows:

	Nouns	Verbs	Adj.	Adv.	Pro.	Intj.	Conj.	Prep.	Total
Total	46	92	31	28	63	0	2	17	279
Dif.	32	40	11	13	12	0	1	6	115
Per cent	16.5	33.0	11.1	10.0	22.6	0	0.7	6.1	100

The measurements and observations for Subject R are as follows:

Subject R: Boy; weight at birth, 7 pounds; age at which walked, 14½ months. Father, German. Height, 5 feet 10 inches. Weight, 140 pounds. Mother, mixed ancestry, including English and Dutch Hebrew and Spanish-Italian. Height, 5 feet 4 inches. Weight, 110 pounds.

Entered Nursery School, December 13, 1920. Age, I year 5 months 21 days. Weight, 25 pounds. Reflexes: knee-jerk—just present, ankle—active, biceps and triceps—just present; Babinski—tried for but not obtained.

Nursery School records give the following accounts of muscular control:

Dec., 1920.—Made for slide, climbed to second step, stepped off backwards, shouting with laughter. Repeated stunt; first attempt at sliding was a success.

March, 1921.—R rushed at slide with spoon in hand. Went up and over the top, sending spoon ahead of him. Repeated twice.

April, 1921.—R mounts and dismounts horses as skilfully as the older children do; throws one leg over the side or walks on it from the rear.

Psychological records of observations made of all the activities of R for given periods of time follow:

Subject R: 2 years 7 months old. Weight, 31.25 pounds. Height, 37.5 inches. Reflexes: knee-jerk—hyperactive; ankle—tried for but not obtained; biceps and triceps—just present; Babinski—tried for but not obtained.

Observed, 9:20–12:20 and from 3:04 P.M. to 4:05.

Activities: Individual play interests: large number of play objects used but usually for a short time; frequently approached adults and leaned against them, showing them his play objects; assumed authoritative attitude over other children, often giving directions; played with dumb-waiter at intervals for less than a minute at each time; played with wheelbarrow, seesaw, wagon

and various objects from 5 to 40 seconds each; fingered watch, 12 minutes.

Motor co-ordination: Climbed steps in hall, one foot at a time, holding railing; climbed steps of slide one foot after other, sliding down frontwards; climbed upon a table 3 feet high with ease; crawled up a ladder sloped very gradually; threw a ball a few feet, using both hands; held spoon with right and left hands interchangeably, feeding himself unassisted; unsuccessful in manipulating a large screw-driver; turned stem winder of watch backwards with thumb and forefinger.

Speech: A large number of correct simple sentences; a few incorrect or incomplete sentences; very few disconnected words; repeated song of 26 words; sings a great deal, often accompanying other activities with singing; total number of words used, 497; of different words, 189. With relation to total time of observation, number of words used per minute is 2.7; the number of different words used per minute is 1.04. Proportion of various parts of speech follows:

	Nouns	Verbs	Adj.	Adv.	Pro.	Intj.	Conj.	Prep.	Total
Total	88	147	52	47	104	2	1	36	477
Dif.	66	62	18	19	12	2	1	9	189
Per cent	18.4	30.8	10.9	9.8	21.8	0.4	0.4	7.5	100

Measurements and observations made two months later follow.

Subject R: Age 2 years 9 months 6 days. Weight 31.75 pounds; height, 37.5 inches. Observed, 9:17 to 11:15 A.M.

Activities. Play is individual and, in general, the impulse is not derived from other children; jouncing board, 2 minutes; pulling wagon, 1 minute; throwing pebbles, 2 minutes; rolling pebbles down plank, 1 minute, 6 seconds; slid 15 times, 11 minutes; hammering nails in board, 6 minutes, and later 5 minutes; pushing himself in wagon, 7 minutes and later 2 minutes; pouring pebbles in bucket, 8 minutes.

Motor Control: Climbed in and out of packing box with ease; climbed up on shelf and down, taking hammer from shelf above; stood erect on jouncing board and joggled; walked upstairs one foot after the other; pulled nail out after driving it in; holds hammer well down from head and has good aim with small lift.

Speech: Many simple sentences, one compound, and one com-

plex; frequent prepositional phrases; pronoun "I" used 30 times; talks as an accompaniment of many activities; marked tendency to rhythmic use of words, syllables, sentences, and songs; total number of words used, 330; of different words, 144. Rate of speech as determined by the number of words per minute is 2.8; by the number of different words per minute, 1.2. Proportion of various parts of speech follows:

	Nouns	Verbs	Adj.	Adv.	Pro.	Intj.	Conj.	Prep.	Total
Total	51	111	39	43	64	2	3	17	330
Dif.	40	53	12	21	9	2	3	4	144
Per cent	15.5	33.6	11.8	13.0	19.4	0.6	0.9	5.2	100

A comparison of the weight and height of the two children shows that until they reach the age of three Subject E is heavier than Subject R, the amount of difference decreasing with increasing age. After this age the weights do not vary by as much as one pound. The absolute increase in height is approximately the same, but the heavier child is lower in stature at all ages. This difference in the relative weight for height would doubtless influence the muscular control, especially of those activities such as walking, climbing, and balancing, which involve general bodily control. The variations in proportionate growth, such as the length of head and limbs in relation to total stature, which is shown in Figure 3, are also factors that seem influential in the development of motor control in these general bodily activities. In activities not involving general bodily control, as use of hammer, or opening of door and also in speech development, E compares more favorably with R, though he is still slightly less capable at the age of three and a half years. *The prediction of the ultimate abilities of the child can not be based upon the muscular control shown at early stages of development, especially before the age of three, unless the individual variation in proportionate growth of body and in the relative weight for height are considered.*

Growth in Height and Weight of Children from Three to Twelve Years of Age

The repeated measurements of height and weight for the children between the ages of three and twelve are given in Tables III to VI inclusive. These measurements are for individuals

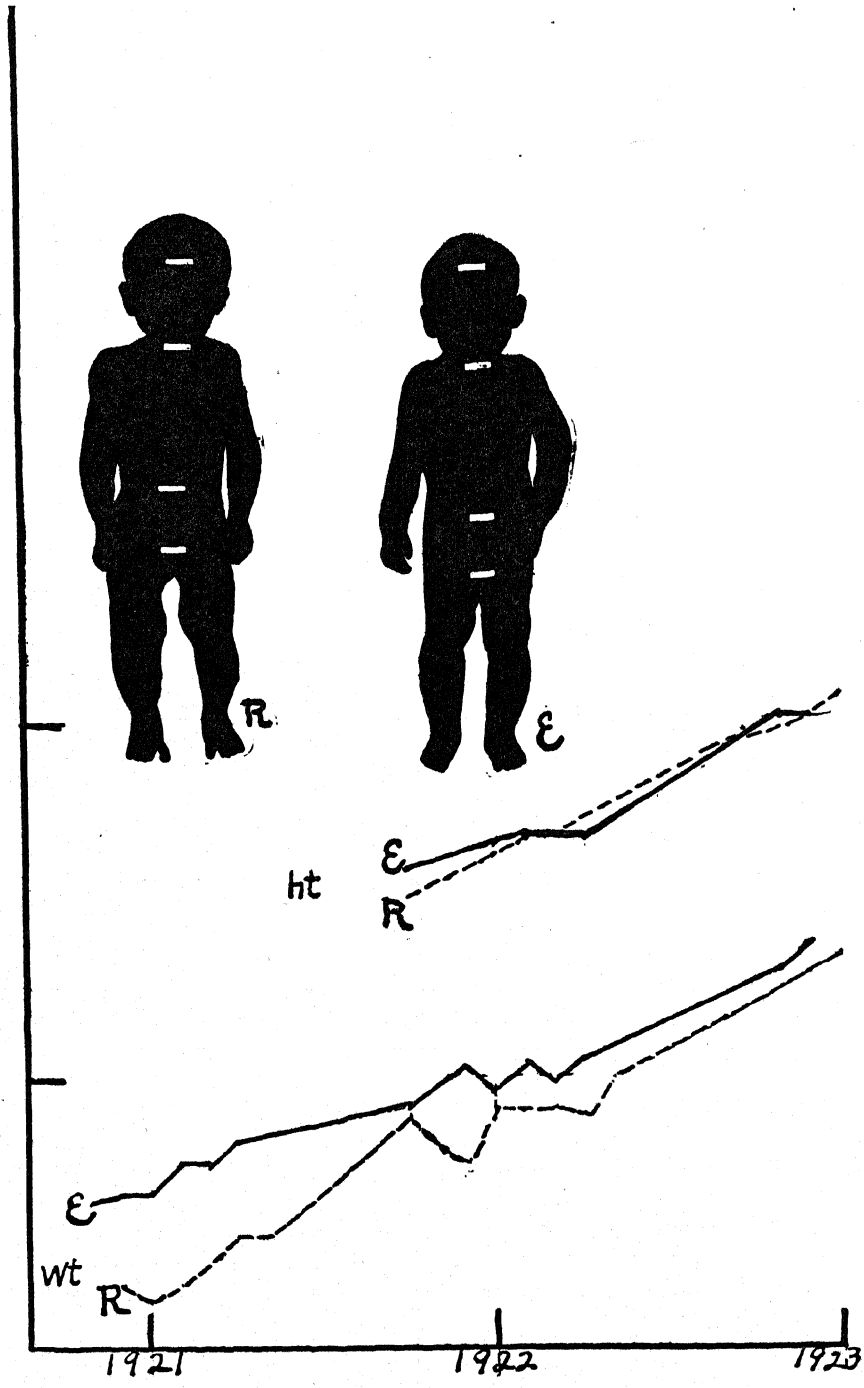

FIG. 3.—Silhouettes of two boys showing bodily proportions at two years of a and growth in height and weight.

Table III

WEIGHT—GIRLS

Individual	Age at 1st Weight	Birth Month	Oct.-Nov.	Dec.-Jan.	Feb.-March	April-May	June-Sept.	Oct.-Nov.	Dec.-Jan.	Feb.-March	April-May	June-Sept.	Oct.-Nov.	Dec.-Jan.	Feb.-March	April-May
1st Weight at Three																
1	3.0	Oct.	33.5	33.5	34.5	....	....	33.5	37.0	37.4	38.3	....	41.4	42.4	43.0	43.7
2	3.0	Nov.	31.8	32.0	32.8	34.0	....	36.2	38.6	38.5	40.7	....	43.6	44.8	47.0	46.5
3	3.5	June	33.3	34.3	34.8	35.0	....	39.3	38.8	40.4	40.8	....	44.1	45.0	44.6	47.3
4	3.5	June	39.8	39.2	39.8	40.5	....	42.2	42.0	42.6	43.0	....	44.7	46.5	47.1	48.7
5	3.5	May	27.2	27.5	29.0	28.8	....	31.3	32.1	32.6	33.9	....	35.6	36.7	37.9	37.5
Average...	....	.....	33.1	33.3	34.2	34.6	....	36.5	37.7	38.3	39.3	....	41.9	43.1	43.9	44.7
1st Weight at Four																
1	4.0	Jan.	....	38.5	40.3	40.7	....	41.8	44.0	43.4	....	....	49.9	51.2	52.1	
2	4.3	Sept.	....	36.0	36.5	35.6	....	38.3	40.2	40.8	42.1	....	42.3	43.2	45.5	
3	4.2	Dec.	....	30.7	31.3	32.1	....	33.2	33.9	34.8	35.4	....	37.0	38.6	39.6	41.6
4	4.6	April	37.4	36.0	36.5	38.5	....	41.0	42.7	42.4	42.5	....	43.5	45.9	46.7	47.6
Average...	....	.....	....	35.3	36.2	36.7	....	38.6	40.2	40.4	40.0	....	43.2	44.7	46.0	44.6
1st Weight at Five																
1	5.2	Aug.	42.0	43.0	43.6	42.4	....	46.5	47.9	46.8	48.3	....	50.0	51.0	51.6	51.3
2	5.6	July	....	44.8	45.4	47.3	....	50.3	50.7	50.7	52.2	....	53.7	52.9	56.1	55.3
3	5.6	June	....	57.0	54.8	61.1	....	65.3	63.7	63.8	67.6	....	69.5	71.3	75.3	77.2
4	5.9	Jan.	42.0	41.8	42.8	43.9	....	47.3	46.5	48.1	49.2	....	54.0	53.5	51.9	55.3
5	5.8	Jan.	36.4	38.7	39.8	40.0	....	41.7	42.0	42.7	43.2	....	43.3	44.4	46.5	47.5
6	5.8	May	....	....	46.5	47.5	....	52.0	50.2	51.9	53.1	....	56.9	56.0	58.1	57.8
7	5.8	Dec.	40.8	41.0	40.0	42.0	....	44.1	45.1	44.7	45.7	....	49.4	49.8	51.1	53.3
8	5.3	Aug.	36.1	36.3	35.5	34.8	....	37.4	37.3	36.2	39.1	....	40.1	40.8	42.5	43.9
9	5.1	Sept.	38.5	39.8	40.2	40.7	....	....	43.6	43.0	43.7	....	44.8	46.5	47.6	47.4
Average...	....	.....	39.3	42.8	43.2	44.4	....	48.1	47.4	47.5	49.1	....	51.3	51.8	53.4	54.3
1st Weight at Six																
1	6.0	Dec.	40.3	40.3	40.4	42.5	....	45.0	47.3	47.5	48.6	....	52.8	53.6	54.3	53.7
2	6.3	July	50.3	50.4	50.0	51.7	....	56.0	55.0	56.9	56.8	....	61.4	60.7	62.4	61.5
3	6.4	July	46.5	47.2	48.5	49.7	....	52.8	52.2	52.8	55.7	....	57.5	58.9	62.0	66.7
4	6.8	March	....	50.3	49.4	51.5	....	53.4	53.9	54.9	54.2	....	57.1	58.4	57.0	59.6
Average...	....	.....	45.7	47.1	47.1	48.9	....	51.8	52.1	53.0	53.8	....	57.2	57.9	58.9	60.4
1st Weight at Seven																
1	7.1	Oct.	52.5	54.5	55.3	56.8	....	59.7	61.5	62.9	64.8	....	70.6	70.2	68.5	69.5
2	7.6	April	46.5	47.3	46.4	49.0	....	52.3	52.8	52.4	54.4	....	57.0	58.2	60.1	61.7
Average...	....	.....	49.5	50.9	50.9	52.9	....	56.0	57.7	57.7	59.6	....	63.8	64.2	64.3	65.6
1st Weight at Eight																
1	8.8	May	....	53.4	54.5	54.6	....	57.2	60.9	61.4	62.8	....	65.6	67.0	69.3	70.0
2	8.9	Dec.	68.5	66.8	67.7	72.7	....	82.8	85.1	87.2	90.7	....	96.4	102.4	104.8	105.7
Average...	....	.....	....	60.1	61.1	63.7	....	70.0	73.0	74.3	76.8	....	81.0	84.7	87.2	87.9
1st Weight at Nine																
1	9.6	Aug.	....	63.0	61.2	61.0	....	64.5	63.0	65.5	66.6	....	69.7	69.2	69.3	71.9

Table IV

WEIGHT—BOYS

Individual	Age at 1st Weight	Birth Month	Oct.-Nov.	Dec.-Jan.	Feb.-March	April-May	June-Sept.	Oct.-Nov.	Dec.-Jan.	Feb.-March	April-May	June-Sept.	Oct.Nov.	Dec.-Jan.	Feb.-March	April-May
1st Weight at Three																
1	3.9	Feb.	36.5	36.7	36.7	37.8	....	40.7	42.0	42.6	42.2	....	46.3	49.3	48.3	47
1st Weight at Four																
1	4.1	Aug.	40.6	41.8	42.5	44.1	....	47.7	....	49.2	....	....	52.5	55.4	57.8	58
2	4.3	July	41.4	41.6	42.2	42.0	....	47.3	48.5	47.8	47.2	....	49.9	41.7		
3	4.5	July	....	33.0	34.3	34.9	....	36.3	36.5	36.8	38.2	....	40.1	40.6	41.9	42
4	4.9	Feb.	46.2	....	46.5	47.4	....	51.0	51.2	51.8	....	....	57.5	59.8	60.7	
Average...	.....	.....	42.7	33.8	41.4	42.1	....	45.6	45.4	46.4	42.7	....	50.0	49.4	53.5	50
1st Weight at Five																
1	5.0	Oct.	46.1	47.4	48.0	....	....	51.1	51.9	53.0	....	....	56.2	56.3		
2	5.5	May	40.7	41.3	42.4	41.9	....	47.2	46.8	48.2	....	....	52.2	53.5	54.5	55
3	5.6	March	45.7	46.2	48.0	48.9	....	49.9	52.5	54.1	54.7	....	56.7	59.8	61.7	62
4	5.6	March	47.7	49.8	50.6	52.9	....	53.5	58.3	59.3	61.9	....	61.5	65.5	66.7	
5	5.8	Dec.	42.0	42.5	43.7	46.3	....	48.3	48.2	49.0	51.2	....	....	54.6	58.1	
6	5.8	Dec.	43.2	44.6	45.1	45.8	....	46.8	49.1	49.8	50.6	....	51.8	54.8	55.4	
7	5.0	Oct.	41.3	43.0	43.6	43.5	....	47.1	47.1	48.0	48.6	....	53.9	55.0	54.8	
8	5.5	May	48.4	49.5	50.5	50.1	....	55.7	56.8	58.1	57.7	....	61.6	64.7	66.8	68
9	5.9	Jan.	51.2	52.8	53.6	54.9	....	57.0	57.2	58.0	59.2	....	61.1	63.5	64.8	66
Average...	.....	.....	45.1	46.3	47.3	48.0	....	50.8	52.0	53.1	54.8	....	56.9	58.6	60.4	63
1st Weight at Six																
1	6.1	Sept.	45.5	....	44.5	44.5	....	47.8	48.8	49.0	51.7	....	54.2	53.6	56.3	56
2	6.1	Sept.	48.4	47.3	48.0	49.6	....	52.0	54.5	51.8	56.0	....	59.6	58.2	59.6	61
3	6.1	Sept.	38.8	39.7	39.7	40.0	....	44.0	43.9	44.2	46.9	....	49.2	50.4	51.6	51
4	6.3	Aug.	41.5	41.6	43.0	42.0	....	45.2	46.0	47.2	48.9	....	51.1	51.5	51.7	53
5	6.7	March	41.5	41.0	42.3	42.2	....	....	46.1	46.1	48.3	....	51.3	50.9		
6	6.9	Jan.	48.0	49.5	49.7	49.7	....	53.9	53.1	54.2	54.3	....	60.1	61.5	63.0	
7	6.11	Nov.	42.6	43.1	43.3	44.6	....	48.5	47.9	47.4	49.2	....	50.1	51.0	50.6	51
Average...	.....	.....	43.7	43.7	44.4	44.7	....	48.6	48.6	48.6	50.8	....	53.7	53.9	55.5	54
1st Weight at Seven																
1	7.1	Sept.	38.7	40.0	40.7	43.5	....	43.7	46.5	46.8	48.8	....	51.3	50.0	51.5	53
2	7.4	June	46.7	48.2	47.4	49.6	....	51.7	52.6	52.8	53.6	....	56.1	57.3	58.6	59
Average...	.....	.....	42.7	44.1	44.1	46.6	....	47.7	49.6	49.8	51.2	....	53.7	53.7	55.1	56
1st Weight at Eight																
1	8.1	Sept.	58.2	59.6	61.3	60.8	....	64.9	68.3	65.5	67.4	....	70.4	72.7	74.8	77
2	8.9	March	....	56.3	55.0	57.5	....	58.7	59.5	59.5	61.4	....	64.8	64.6	64.8	65
3	8.9	Feb.	52.3	53.5	52.4	55.0	....	....	58.8	58.4	61.8	....	62.7	64.2		
Average...	.....	.....	55.3	56.5	56.2	57.8	....	61.8	62.2	61.1	63.5	....	66.0	67.2	69.8	71
1st Weight at Nine																
1	9.0	Oct.	55.2	56.8	57.5	58.5	....	61.9	63.6	62.5	64.8	....	67.5	67.5	68.5	70
2	9.0	Oct.	53.5	56.5	56.0	57.7	....	58.7	59.5	59.5	61.4	....	64.8	64.6	64.8	65
3	9.3	June	68.1	66.8	65.0	66.2	....	69.2	72.8	69.0	....	....	75.0	79.2	80.1	84
4	9.8	Feb.	62.7	64.3	65.0	68.6	....	69.0	72.9	71.6	74.2	....	76.3	78.0	80.8	83
Average...	.....	.....	59.9	61.1	60.9	62.8	....	64.7	67.2	65.7	66.8	....	70.9	72.3	73.6	75

Table V

HEIGHT—GIRLS

Individual	Age at 1st Height	Birth Month	Oct.-Nov.	Dec.-Jan.	Feb.-March	April-May	June-Sept.	Oct.-Nov.	Dec.-Jan.	Feb.-March	April-May	June-Sept.	Oct.-Nov.	Dec.-Jan.	Feb.-March	April-May
1st Height at Three																
1	3.0	Oct.	36.8	37.5	38.0	....	...	40.0	40.6	40.8	41.1	....	42.6	42.9	43.5	43.9
2	3	Nov.	37.8	38.5	38.5	39.0	...	[illegible]	[illegible]	[illegible]	[illegible]	...	44.1	44.3	44.9	45.4
3	3.5	June	37.8	38.5	38.5	38.5	....	[illegible]	[illegible]	[illegible]	[illegible]	...	43.7	44.1	44.4	45.0
4	3.5	June	38.8	39.0	40.0	40.5	....	[illegible]	[illegible]	[illegible]	[illegible]	...	43.9	44.3	44.6	45.1
5	3.5	May	35.5	35.5	36.0	36.5	....	38.3	38.8	38.8	39.2	....	41.0	40.9	41.4	41.9
Average...	....	.....	37.3	37.8	38.2	38.6	....	40.3	40.9	41.1	41.6	....	43.1	43.3	43.8	44.3
1st Height at Four																
1	4.0	Jan.	....	41.3	42.0	42.0	....	43.8	43.8	44.4	....	....	....	46.5	46.9	47.5
2	4.3	Sept.	....	41.0	41.0	41.5	....	43.3	43.2	43.5	44.1	....	45.5	46.0	46.3	
3	4.2	Dec.	....	39.8	39.8	40.5	....	42.1	42.3	42.3	43.0	....	44.5	45.1	45.4	45.8
4	4.6	April	40.8	41.3	41.8	42.0	....	43.4	44.0	44.5	45.0	....	46.0	46.2	46.8	47.3
Average...	....	.....	....	40.9	41.2	41.5	....	43.2	43.3	43.7	44.0	....	45.3	45.9	46.4	46.9
1st Height at Five																
1	5.2	Aug.	43.3	43.6	44.5	44.8	....	46.0	46.3	46.5	47.0	....	48.1	48.3	48.4	48.8
2	5.6	July	....	46.4	46.6	47.0	....	48.3	48.7	49.2	49.5	....	50.7	51.2	51.5	52.2
3	5.6	June	....	48.0	48.6	49.3	....	50.4	51.0	51.5	52.1	....	53.0	53.6	53.8	54.7
4	5.9	Jan.	43.3	43.4	44.2	44.8	....	46.3	46.6	46.7	47.4	....	48.8	49.0	49.2	49.8
5	5.8	Jan.	42.7	42.8	43.0	43.3	....	44.7	45.0	45.2	45.9	....	47.0	47.2	47.4	47.8
6	5.8	May	....	....	45.9	46.2	....	47.5	47.7	47.9	48.5	....	49.6	49.9	50.0	52.6
7	5.8	Dec.	42.4	42.9	43.8	43.8	....	45.2	45.4	45.8	46.2	....	47.5	47.8	48.2	48.3
8	5.3	Aug.	40.0	40.2	40.5	41.0	....	42.4	42.6	42.8	43.3	....	44.4	44.7	45.1	45.4
9	5.1	Sept.	42.5	42.8	43.5	43.8	....	44.7	44.9	45.4	45.9	....	46.9	47.0	47.3	47.5
Average...	....	.....	42.4	43.8	44.5	44.9	....	46.2	46.5	46.8	47.3	....	48.4	48.7	49.0	49.7
1st Height at Six																
1	6.0	Dec.	43.4	43.9	43.7	44.3	....	45.8	46.6	46.5	47.1	....	48.2	48.5	49.0	49.6
2	6.3	July	45.2	45.5	46.1	46.2	....	47.3	47.9	48.3	48.7	....	49.2	50.0	50.3	50.3
3	6.4	July	46.5	46.7	47.3	47.5	....	48.9	49.2	49.4	50.1	....	51.1	51.3	51.8	52.5
4	6.8	March	....	47.4	47.9	48.2	....	49.5	49.7	50.0	50.5	....	51.4	51.7	52.1	52.4
Average...	....	.....	45.0	45.9	46.3	46.6	....	47.9	48.4	48.6	49.1	....	50.0	50.4	50.8	51.2
1st Height at Seven																
1	7.1	Oct.	50.5	50.5	50.8	51.2	....	52.8	52.9	53.5	54.0	....	54.9	55.3	55.5	56.1
2	7.6	April	46.7	47.3	47.6	48.0	....	49.4	49.5	50.0	50.4	....	51.5	51.7	52.0	52.6
Average...	....	.....	48.6	48.9	49.2	49.6	....	51.1	51.2	51.8	52.2	....	53.2	53.5	53.8	54.4
1st Height at Eight																
1	8.8	May	....	51.3	51.5	51.9	....	53.6	53.6	53.7	54.3	....	55.4	55.6	55.9	56.3
2	8.9	Dec.	52.4	52.8	53.1	53.5	....	....	55.7	57.0	57.7	....	59.2	60.1	60.2	60.6
Average...	....	.....	....	52.6	52.6	52.7	....	....	54.7	55.4	56.0	....	57.3	57.9	58.1	58.5
1st Height at Nine																
1	9.6	Aug.	....	52.1	52.3	52.6	....	53.4	53.6	54.1	54.4	....	55.2	55.6	56.0	56.2

Table VI

HEIGHT—BOYS

Individual	Age at 1st Height	Birth Month	Oct.-Nov.	Dec.-Jan.	Feb.-March	April-May	June-Sept.	Oct.-Nov.	Dec.-Jan.	Feb.-March	April-May	June-Sept.	Oct.-Nov.	Dec.-Jan.	Feb.-March	April-May
1st Height at Three																
1	3.9	Feb.	40.3	40.8	41.0	42.0	....	43.1	43.6	43.6	44.1	....	46.0	46.7	46.7	47.2
1st Height at Four																
1	4.1	Aug.	41.8	42.0	42.5	43.3	....	45.0	....	45.9	....	....	47.9	48.7	49.1	
2	4.3	July	43.5	43.8	44.8	45.0	....	47.0	47.4	48.3	....	....	48.9	49.6		
3	4.5	July	....	40.3	40.5	41.0	....	41.3	42.0	42.3	42.9	....	43.7	44.3	44.5	44.9
4	4.9	Feb.	42.6	....	43.8	44.0	....	45.7	46.0	46.3	....	....	48.2	49.0	49.3	
Average...	.....	.....	42.6	42.0	42.9	43.3	....	44.8	45.1	45.7	....	....	47.2	47.9	47.6	
1st Height at Five																
1	5.0	Oct.	45.0	45.0	46.0	....	....	47.7	47.9	48.4	....	....	50.3	50.5		
2	5.5	May	43.0	43.0	43.8	44.3	....	45.5	46.1	46.0	....	....	47.5	48.3	48.8	48.9
3	5.6	March	44.0	44.7	45.0	46.0	....	47.2	47.2	47.6	48.1	....	49.3	50.1	50.2	50.9
4	5.6	March	45.5	45.7	45.9	46.7	....	48.1	48.3	48.5	49.2	....	50.3	50.7	50.8	
5	5.8	Dec.	44.8	45.5	45.6	46.3	....	47.9	48.2	48.4	49.0	....	....	50.4	50.8	
6	5.8	Dec.	43.3	43.8	44.1	44.7	....	46.0	46.2	46.5	47.1	....	48.2	48.5	48.7	
7	5.0	Oct.	44.0	44.3	44.8	45.3	....	46.3	46.6	46.9	47.4	....	48.5	49.1	49.4	
8	5.5	May	45.0	45.4	46.0	46.5	....	47.6	47.9	48.3	49.2	....	50.6	51.1	51.6	51.8
9	5.9	Jan.	46.1	46.0	46.9	47.5	....	49.0	48.9	49.4	50.2	....	51.1	51.5	51.7	52.7
Average...	.....	.....	44.5	44.8	45.3	45.9	....	47.3	47.5	47.8	48.6	....	49.5	50.0	50.3	51.1
1st Height at Six																
1	6.1	Sept.	43.3	....	44.0	44.2	....	45.5	45.9	46.1	46.6	....	47.5	47.9	48.4	48.8
2	6.1	Sept.	46.2	46.3	47.0	47.3	....	48.5	49.0	49.4	50.1	....	50.6	50.9	51.5	52.1
3	6.1	Sept.	42.5	42.5	42.9	43.2	....	44.3	44.7	45.0	45.5	....	46.5	46.5	46.9	47.4
4	6.3	Aug.	43.7	43.8	44.0	44.8	....	45.9	46.2	46.6	47.2	....	48.0	48.3	48.8	49.5
5	6.7	March	44.4	45.0	45.3	45.5	....	46.7	47.0	47.3	47.8	....	48.9	49.3		
6	6.9	Jan.	47.9	48.3	48.5	48.7	....	50.0	50.2	50.6	51.1	....	52.4	52.8	53.1	
7	6.11	Nov.	44.2	44.2	44.7	45.2	....	46.4	46.4	46.3	47.1	....	47.9	48.5	48.6	48.8
Average...	.....	.....	44.6	45.0	45.2	45.6	....	46.8	47.1	47.3	47.9	....	48.8	49.2	49.7	49.3
1st Height at Seven																
1	7.1	Sept.	45.0	45.3	45.9	46.3	....	47.9	48.1	48.6	49.1	....	50.1	50.3	50.6	51.0
2	7.4	June	46.2	46.6	47.0	47.6	....	48.9	49.0	48.9	50.0	....	50.7	50.7	50.8	51.6
Average...	.....	.....	45.6	46.0	46.5	47.0	....	48.4	48.6	48.8	49.6	....	50.4	50.5	50.7	51.3
1st Height at Eight																
1	8.1	Sept.	51.1	51.6	52.1	52.2	....	53.1	54.0	54.4	55.0	....	55.9	56.1	56.1	56.6
2	8.9	March	....	49.7	49.8	50.5	....	51.7	51.7	52.0	52.5	....	53.5	53.4	53.5	54.2
3	8.9	Feb.	51.2	51.1	51.6	51.8	....	52.3	53.1	53.6	54.0	....	55.0	55.2		
Average...	.....	.....	51.2	50.8	51.2	51.5	....	52.7	52.9	53.3	53.8	....	54.8	54.9	54.8	55.4
1st Height at Nine																
1	9.0	Oct.	49.5	49.6	50.1	50.2	....	51.7	51.7	51.9	52.5	....	53.1	53.3	53.6	53.9
2	9.0	Oct.	48.7	49.3	49.5	50.0	....	51.5	51.2	51.5	52.2	....	53.1	53.1	53.3	53.4
3	9.3	June	51.0	51.2	51.5	51.9	....	53.0	53.0	53.4	....	....	54.5	54.9	55.0	55.5
4	9.8	Feb.	51.6	51.8	52.6	53.1	....	54.6	54.7	55.0	55.7	....	56.8	56.7	57.0	57.9
Average...	.....	.....	50.2	50.5	50.9	51.3	....	52.7	52.7	53.0	53.5	....	54.4	54.5	54.7	55.2

grouped according to the age at which the first measurements were made. The measurements were made without clothing, at the time of the physical examination and at intervals of two months for certain periods of time as mentioned above. The measurements are classified as Oct.-Nov., to indicate that they fell within one of those two months. Only those children who had been measured at intervals of 55 to 65 days for two or more years are included. The majority of the children had their first measurements in October, but some were not measured until November. If the weight falling at this interval was one taken with clothing, a correction for this was made in accordance with the allowance for clothing made by Baldwin (1). The Weight-height indices used in the relation of anatomical to mental growth were computed from measurements taken without clothing at the same time that the mental tests were made or on the nearest date to this test period.

The averages for children of the same sex and age group are given. Growth curves plotted from these averages are shown in Figure 2. The age norms derived by Baldwin (1) are also plotted. The height curves plotted for the same children from year to year are similar in form to the curves of norms. If a group has an average above the norm at the first measurement, the group remains above the norm. The girls are above the norm in height at all ages with few exceptions. Some groups of boys are above, others are below the norm. The variation from the measures obtained for large groups of children at these ages are as great as four inches for the group who were first measured at three. This group is also taller than the other two groups which their ages overlap.

The same tendencies are shown in the comparison of the weight curves with the norms. The girls are above the Baldwin norms throughout; the boys that were taller are also heavier and the same groups of boys that were below the norms in height are also below in weight. A marked difference in rate of growth is shown by the two girls who were first measured at eight and made a spurt from nine to eleven. So great a spurt is not shown by the boys though an acceleration is shown at eleven. The difference in rate of growth is clearly illustrated by the weight curve for the nine five-year-old boys in comparison with the curves for the four- and six-year-olds.

The seasonal variation can not be accurately determined

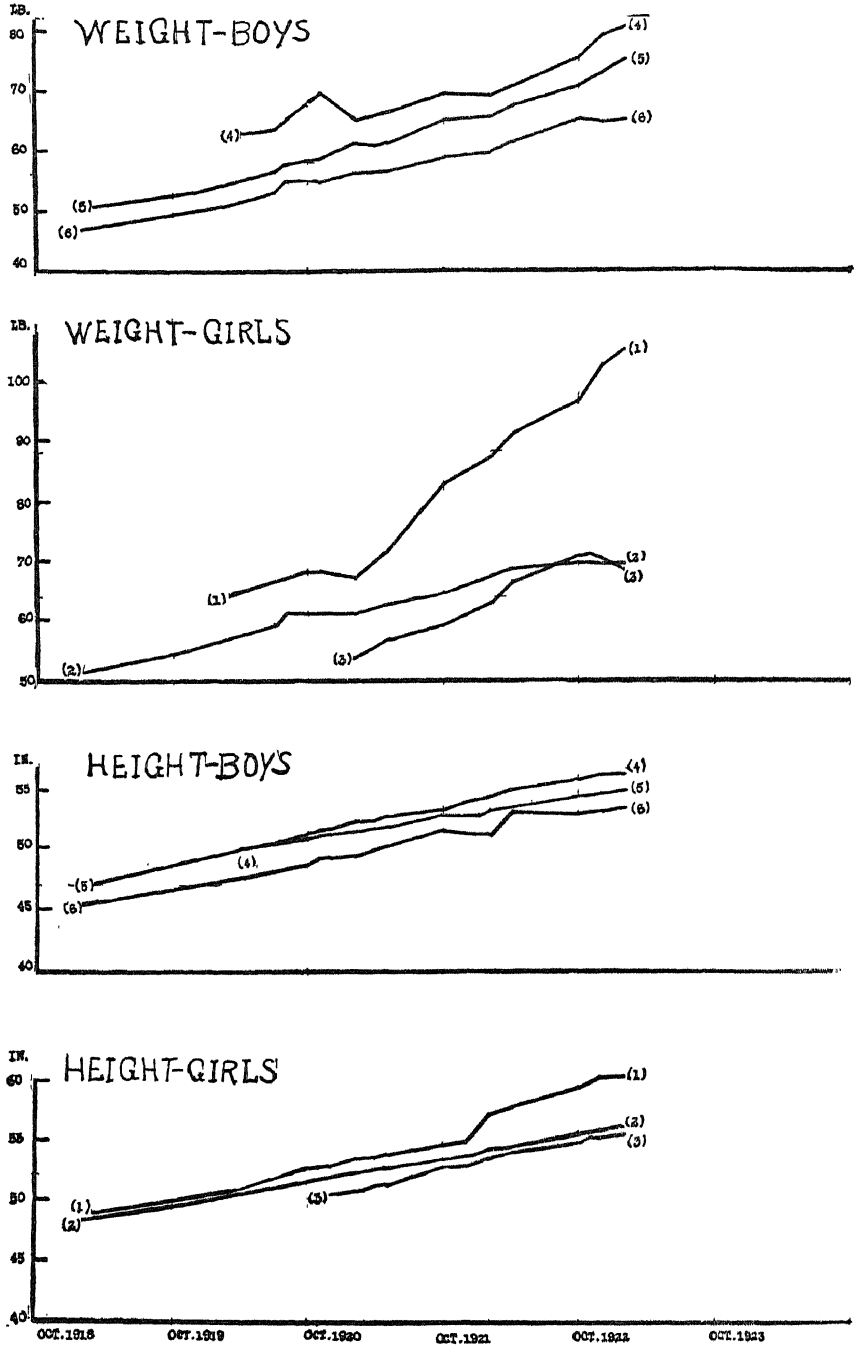

FIG. 4.—Individual growth curves in height and weight. Girls A, B and C are represented by (2), (3) and (1) respectively; (4), (5) and (6) are boys.

without measurements during the summer months when the children were not under observation. Previous studies (9) (17) have shown that the greatest gain in weight occurs in the months of August, September, October, and November. This is substantiated by the following averages of variations in measure-

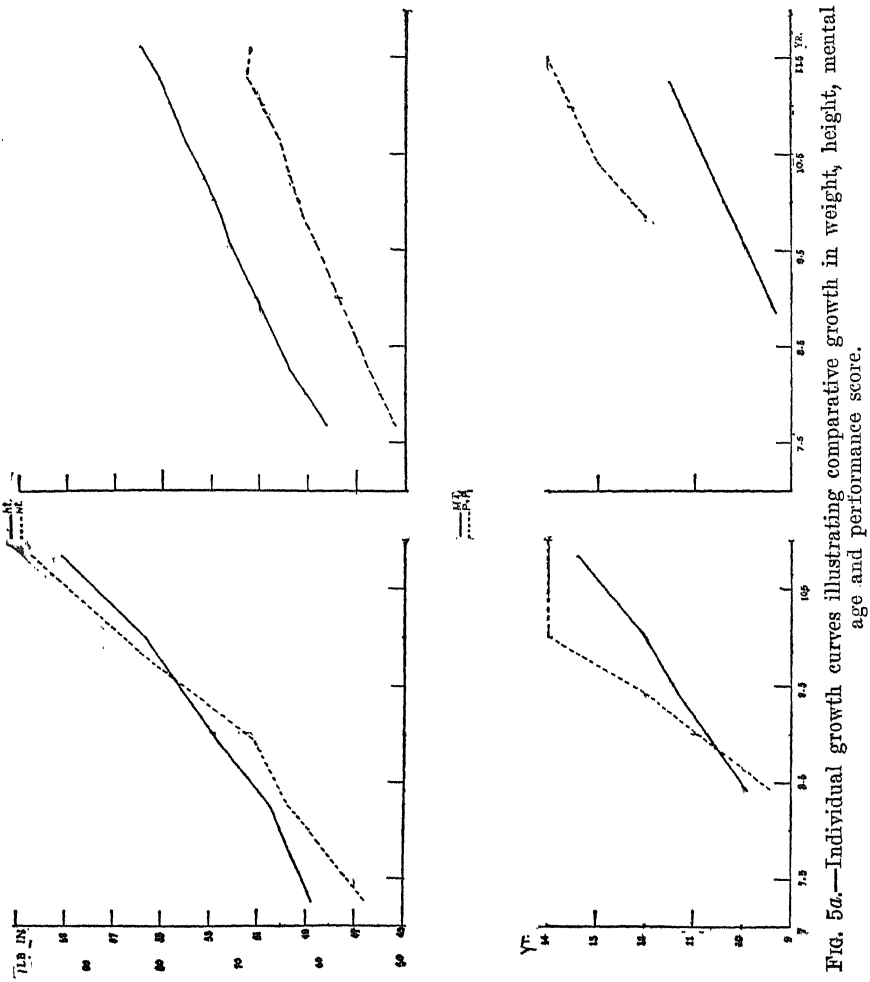

Fig. 5a.—Individual growth curves illustrating comparative growth in weight, height, mental age and performance score.

ments for the intervals October-November to April-May and April-May to the following October-November. The greater gain in weight and height for both sexes at all ages is shown for the period from April or May to October or November.

The individual variations in growth in weight are of most interest and importance. Some individuals fall within the groups classed by Baldwin as tall or short and the growth in

height corresponds closely to that suggested by Baldwin. The variations in weight are less predictable, especially for ages seven to twelve. These are illustrated in Figure 4. It is shown that one girl, A, who was first weighed at the age of 9.6 years gained only 8.6 pounds in 28 months, while two other girls, B

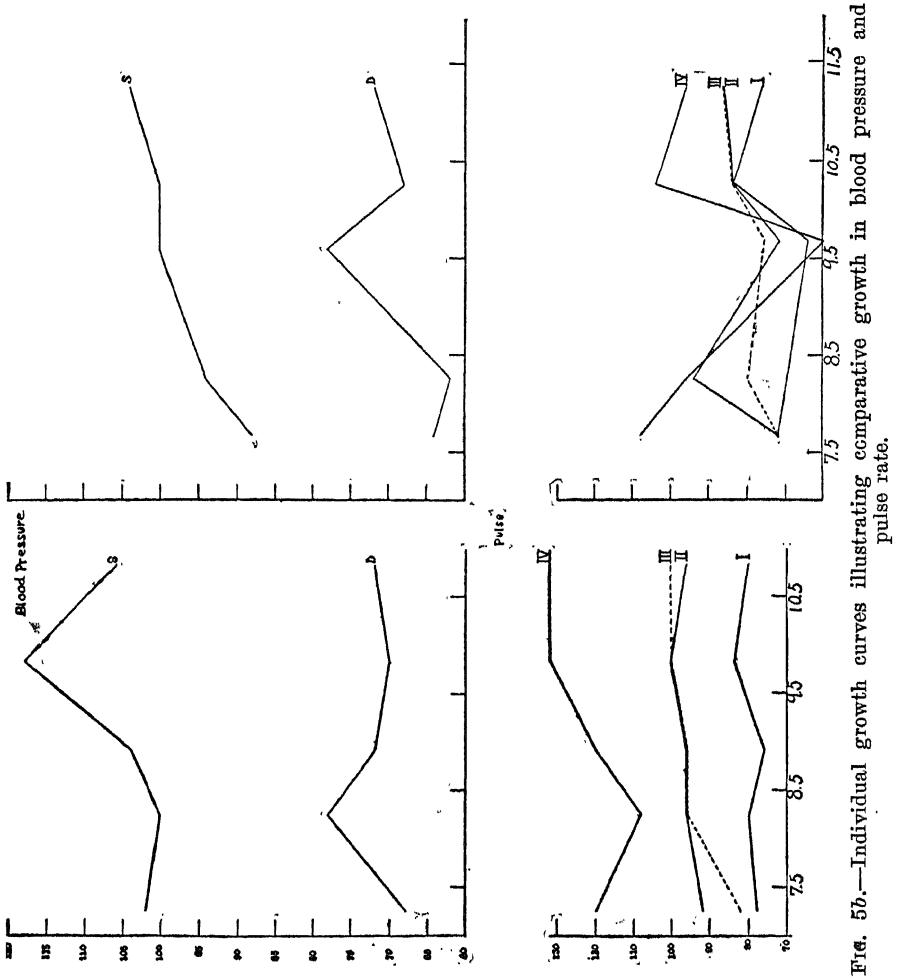

FIG. 5b.—Individual growth curves illustrating comparative growth in blood pressure and pulse rate.

and C, who were first weighed at ages 8.8 and 8.9 years gained respectively 16.6 and 39.2 pounds within the same period. The girl, C, making the greatest gain was also the heaviest of the three at the first weighing.

Other phases of the growth of the two girls who were first weighed at 8.8 and 8.9 years are illustrated in Figures 5*a* and 5*b*. The Mental Age (Stanford Revision) and the Median Mental Age

(Performance Scale) show little differences in rate of mental growth. Subject B, who grew less rapidly in weight and height, shows greater steadiness in motor control and greater speed in co-ordinated movements during these years. Subject C, who matured earlier than the other girls of the group, showed better form in general bodily control than B but was less precise in the use of smaller groups of muscles. The blood pressure for C, who is relatively heavier for her height than is B, is higher at all ages and the greatest change occurs at the age when the greatest increase in Weight-Height Index is found. The pulse rate is also more rapid for C with a much greater change after exercise; the pulse rate for B, however, seems very erratic. We have a picture of two girls of the same chronological age widely different in bodily traits and in specific mental abilities. The one who is less robust has an inheritance that would partially explain certain neurotic tendencies that have been observed, and there were factors in the home environment that would tend to accentuate her irritability. While on a somewhat lower level in general mental ability as measured by the Stanford Scale, she has, however, certain very desirable specific abilities. From an early age her drawings and paintings have shown originality and have indicated marked artistic ability. An appreciation of fantastic stories and the tendencies toward rhythmic responses of various forms have also been observed. After continued activity requiring the repetition of simple co-ordinated movements the rhythm was frequently lost and great effort was exerted. Instead of regular co-ordinated movements, explosive and jerky movements were made. In certain general bodily movements there was a tension of muscles that interfered with ease and efficiency. There was improvement in the adaptation made to the group as she grew older though a high nervous irritability persisted.

The smaller numbers in our groups might cause greater fluctuations in curves of growth in height and weight than averages for larger groups show. These fluctuations are more marked for some groups than for others, as illustrated by the three groups of boys at ages five, six, and seven in Figure 2, but it is shown that different children grow at different rates at the same chronological ages. The group of boys who were first measured at five are from eight to ten pounds heavier than the group who were first measured at six and vary as much from the curve of norms at certain stages of growth. At ages seven to

seven and a half years the three overlapping curves are widely separated, the variation reaching sixteen pounds. For children so young as these are it is significant that this constant tendency toward widely variant values of weight for children of the same chronological age is found. If the relative weight for height at a given chronological age for a given sex is used as a criterion of physical fitness, it is evident that each age and sex group will include subdivisions of children who are growing at the same rate throughout a period of years, and some of these are considered physically unfit. This criterion of fitness, which has received wide application, has been determined by obtaining averages for large groups of children at different ages, irrespective of hereditary tendencies. Until the rate of growth and variations in relative weight for height for different stocks have been determined, it is unwise to adopt such a criterion of physical fitness. The uncritical adoption of this standard is not only dangerous in application because of the unreliability of the standard as an index of physical fitness, but also because the acceptance discourages attempts at determination of true indices.

Relation of Weight-Height Index to Pulse Rate, Blood Pressure, and Mental Development

Norms for pulse rate and blood pressure for children have not been established. The measures frequently used as standards are based upon too few cases, so far as available data indicate, without adequate control of conditioning factors that influence comparative ratings. Our own data do not fully satisfy such conditions since the diet, time of day, preceding activity, and emotional state can not be assumed equivalent although attempts were made to make them practically so. However, we have obtained averages for the different ages because they constitute the best standard now available for the study of the individual child. These standards are used in the following comparative study of the growth of these children who have been under the environment offered by the same school. The averages are given in Tables VII and VIII.

An increase in blood pressure with increasing chronological age is shown. The number in each age group for either sex is

tolic and diastolic blood pressure readings for the 168 children studied does not show constancy for the ages below nine that previous investigators have indicated. Sladkof (20) gives results for 600 children from one day to fifteen years of age. He concludes that the blood pressure from the end of the first week remains practically constant until nine, after which it rises in a small degree until the eleventh year for girls, and the twelfth year for boys, is reached. From that time it rises steadily until the fifteenth year when the adult pressure of 120 is almost reached.

We find no definite sex differences in blood pressure at this

Table VII

Blood-Pressure / Age	Horizontal					Vertical				
	Systolic			Diastolic		Systolic			Diastolic	
	No.	Range	Av.	Range	Av.	No.	Range	Av.	Range	Av.
Boys										
yr. yr. mo.										
1 to 1 11	1	.....	84.0							
2 to 2 11	5	78– 94	87.6	62–68	63.6	2	78– 88	83.0	.....	62.0
3 to 3 11	6	80– 96	90.6	58–72	66.6	4	82– 96	91.0	60–70	66.5
4 to 4 11	14	80–104	91.1	54–78	65.1	7	84–104	89.4	50–78	64.3
5 to 5 11	13	80–110	91.5	56–76	66.2	4	84–110	93.5	58–76	66.0
6 to 6 11	15	88–110	99.0	48–78	69.0	9	90–110	102.2	56–76	70.2
7 to 7 11	17	78–106	96.3	56–76	68.1	7	82–106	93.4	64–74	68.0
8 to 8 11	12	84–110	98.8	62–82	72.3	3	90–100	95.3	64–76	70.0
9 to 9 11	11	94–106	102.4	68–84	74.4	3	98–108	103.3	68–76	72.0
10 to 10 11	5	98–118	110.6	72–84	76.0	2	116	116.0	78–84	81.0
11 to 11 11	3	106–112	109.3	72–76	74.0					
Girls										
1 to 1 11	1	84	84.0	62	62.0	1	84	84.0	62	62.0
2 to 2 11	1	.....	94.0	.....	66.0					
3 to 3 11	2	78– 84	81.0	54–62	58.0	1	.....	80.0	.....	62.0
4 to 4 11	10	78– 98	88.0	54–72	61.6	7	78– 98	89.3	56–68	63.4
5 to 5 11	12	78–108	94.3	56–76	65.2	4	88–100	94.5	60–70	63.5
6 to 6 11	13	88–112	93.0	56–82	67.2	9	88–112	98.4	56–82	69.1
7 to 7 11	11	88–112	98.2	62–84	70.5	4	88–112	102.5	68–82	76.0
8 to 8 11	9	94–104	102.0	62–78	71.3	5	92–106	100.8	58–72	66.8
9 to 9 11	4	98–118	105.5	70–78	73.0					
10 to 10 11	2	100–106	103.0	68–72	70.0	1	.....	100.0	.....	72.0
11 to 11 11	1	.....	104.0	.....	72.0					

early age. An increase due to change from horizontal to vertical position is indicated by the range of values (Table IX), but direct comparison of the averages cannot be made because of the reduction in number of cases for the vertical position.

The influence of weight and height is important. The systolic blood pressure was correlated with the Weight-Height Index for 191 cases, giving a coefficient of 0.52±.03. When the factor of chronological age was eliminated by the partial correlation method, the coefficient obtained was 0.30±.04. This is not a high value but indicates the tendency for the blood pressure of individuals to increase with an increasing ratio of weight to height. The coefficient is more significant because of the consistent trend in the relationship from year to year shown for the smaller

Table VIII

Pulse-rate	Horizontal			Vertical			After Jumping			1 Minute After		
Age	No.	Range	Av.	No.	Range	Av.	No.	Range	Av.	No.	Range	Av.
Boys												
yr. yr. mo.												
1 to 1 11	4	92–124	112.0									
2 to 2 11	7	88–120	101.7	5	92–120	109.6	1	144	144.0	1	96	96.0
3 to 3 11	6	84– 96	89.3	6	84–104	94.6	4	112–168	130.0	4	84– 96	93.0
4 to 4 11	14	76–108	93.1	14	84–116	99.1	13	44–156	115.7	13	84–120	95.4
5 to 5 11	12	72– 96	85.0	14	80–108	94.3	14	88–144	117.7	14	84–110	90.7
6 to 6 11	15	68–100	84.8	15	80–116	92.5	15	84–156	118.4	14	72–108	88.8
7 to 7 11	16	72– 92	80.7	17	68–196	96.1	17	84–156	121.2	17	72–120	92.0
8 to 8 11	12	56– 96	79.6	12	68–120	88.0	12	84–168	124.6	12	64– 96	83.6
9 to 9 11	11	64– 92	77.8	11	76–184	97.8	11	96–168	124.0	11	68–104	83.3
10 to 10 11	5	76– 84	81.6	5	64– 92	84.0	5	76–120	105.6	5	80– 92	84.8
11 to 11 11	3	64– 88	76.6	3	72– 92	81.3	3	96–144	120.0	3	78–100	87.3
Girls												
1 to 1 11	2	96–100	98.0	2	100–112	106.0						
2 to 2 11	4	92–108	103.0	3	96–116	106.6						
3 to 3 11	7	88–108	97.7	5	84–120	104.0	4	108–120	117.0	3	88–100	93.3
4 to 4 11	11	84–108	92.0	10	84–116	100.0	9	96–168	132.0	9	76–120	98.6
5 to 5 11	13	80–104	90.1	13	84–112	96.3	12	84–156	118.3	11	80–120	98.5
6 to 6 11	13	76–108	91.0	13	76–120	97.6	13	96–168	134.7	13	76–120	96.3
7 to 7 11	11	72–120	87.4	11	72–116	94.5	11	96–160	122.5	11	72–124	94.2
8 to 8 11	8	76– 96	85.5	9	80–132	98.6	9	96–156	129.3	9	80–120	96.2
9 to 9 11	4	64– 84	76.0	4	76–100	88.0	4	60–132	105.0	4	72–100	87.0
10 to 10 11	2	80– 84	82.0	2	84– 96	90.0	2	104–132	118.0	2	84–100	92.0
11 to 11 11	1	.....	76.0	1	.....	84.0	1	.....	96.0	1	.....	84.0

group. For this group, the coefficient of 0.63±.07 was obtained and eliminating the factor of age, this becomes 0.41±.10; a year later the respective coefficients for the same group, with a loss of four cases, were 0.55±.09 and 0.25±.13. *For determination of age or sex differences in blood pressure, groups comparable as to relative weight for height should be studied.*

The pulse rate shows a decrease with increasing chronological age for the 181 cases studied. There are fluctuations, and no constant retardation is shown, but the range and average for each age group and sex shows this trend. This finding is in accordance with that of other investigators. Between the ages

Table IX

VARIATIONS IN BLOOD-PRESSURE: I. HORIZONTAL; II. VERTICAL; III. AFTER JUMPING

Age	Difference Between II and I				Difference Between III and II			
	Systolic		Diastolic		Systolic		Diastolic	
	No.	Average	No.	Average	No.	Average	No.	Average
Girls								
1								
2								
3	1	−4	1	0				
4	7	2.14	7	1.71	2	−2	2	1
5	4	1.5	4	2	1	−8	1	0
6	9	−0.222	9	1.56	4	2	4	−0.5
7	4	2.5	4	4	3	−4	3	12
8	5	0.4	5	−2	4	2.5	4	5.5
9								
10	1	0	1	4	1	0	1	2
11								
Boys								
1	4	0	4	−0.5	3	0	3	1.33
2	1	0	1	0	1	0	1	0
3								
4	7	0.57	7	2.86				
5	4	1.5	4	−0.5	2	0	2	1
6	9	0.44	9	0.67	6	0.67	6	1.67
7	7	1.72	7	2.86	4	0.5	3	−0.67
8	3	0.67	3	0.67	2	−1	2	0
9	3	5.3	3	2	3	−2	3	0
10	2	−1	2	5	2	2	2	2
11								

of four and eight, inclusive, the girls show a faster rate in general. There is a difference of opinion as to the influence of sex, Gundobin (7) holding that sex has no bearing upon pulse frequency. He believes that the slower pulse of the male is due to his greater weight. Vierordt (26) thinks the pulse is of the same frequency in both sexes up to five years. Trousseau (25) claims that all female children from the age of three months upward have a higher frequency than males of a corresponding age. We have so few cases below five in each age group that definite sex comparison is not justified, but the tendency for the girls to have a faster rate after four is more definite than for the earlier ages.

The weight and height are doubtless factors that also influ-

Table X

VARIATIONS IN PULSE RATES: I. VERTICAL; II. IMMEDIATELY AFTER JUMPING; III. ONE MINUTE LATER

Age	Difference Between II and I		Difference Between III and II	
	Number of Cases	Average	Number of Cases	Average
Girls				
1				
2				
3	3	20.00	3	−23.33
4	9	32.9	4	−33.33
5	12	22.33	11	−10.18
6	13	29.23	13	−38.46
7	11	28.00	11	−28.37
8	9	30.67	9	−33.1
9	4	17.00	4	−18.25
10	2	28.00	2	−26.00
11	1	12.00	1	−12.00
Boys				
1	4	38.00	4	−40.00
2	1	52.00	1	−48.00
3				
4	13	17.85	13	−20.3
5	14	22.43	14	−27.0
6	15	26.13	14	−31.43
7	17	31.18	17	−29.18
8	12	36.67	12	−41.00
9	11	35.64	11	−40.73
10	5	21.6	5	−20.8
11	3	38.67	3	−32.67

ence the pulse rate and that vitiate direct sex and age comparisons without consideration of these factors. The relative weight for height does not seem to influence as greatly the pulse rate for our group as it did the blood pressure. The coefficient of correlation obtained for the horizontal pulse rate and the Weight-Height Index was —0.49±.08; and a year later it was —0.44±.08. This suggests a decrease in pulse rate with an increased weight for height. If the influence of chronological age is eliminated, these coefficients become respectively +0.002± .10 and —0.25±.10. The reliability of this relation is certainly not established for this group.

Table XI

COEFFICIENTS OF CORRELATION BETWEEN PHYSICAL AND MENTAL TRAITS

	Number of Cases	Range	Average	S.D.	r	r with Chronological Age Constant	r with Wt.-Ht. Index Constant	r with Blood Pressure Constant
Weight-Height Index with:								
Chronological age (months)	191	36–150	78.6	24.7	0.70 ± .02	.....	.....	0.61 ± .03
Pulse—horizontal	39	56–108	87.87	10.2	−0.49 ± .08	0.002 ± .10		
A year later	36	76–108	86.77	8.1	−0.44 ± .08	−0.25 ± .10		
Blood pressure systolic	191	78–118	97.0	8.7	0.52 ± .03	0.30 ± .04		
pecial group	26	80–108	92.53	7.5	0.63 ± .07	0.41 ± .10		
A year later	22	84–120	100.27	8.4	0.55 ± .09	0.25 ± .13		
Dynamometer	98	2–23	10.88	3.2	0.68 ± .04	0.37 ± .05		
Tapping—fatigue index	44	−15–12	−2.50	5.1	0.12 ± .10	0.28 ± .09		
Steadiness—contact in holes 1, 2, and 3	67	32–0	8.46	8.8	0.06 ± .08	−0.04 ± .08		
Mental age (months)	191	40–171	95.0	30.2	0.68 ± .02	0.044 ± .05		
Blood Pressure (systolic) with:								
Chronological age (months)	191	36–150	78.6	24.7	0.47 ± .03	.....	0.17 ± .04	
Weight (pounds)	191	30.5–96.4	47.1	10.8	0.56 ± .03	0.34 ± .04		
Height (inches)	191	37.5–59.2	45.6	4.6	0.57 ± .03	0.39 ± .04		
Mental age (months)	191	40–171	95.0	30.2	0.42 ± .04	0.02 ± .07		
Pulse—Variation II–I, with:								
Chronological age (months)	41	45–135	82.3	24.2	0.12 ± .10			
Mental age (months)	41	46–161	94.5	28.8	0.17 ± .10	0.189 ± .10		
Pulse—Horizontal with:								
Chronological age (months)	36	42–135	80.9	20.8	−0.39 ± .09			

The coefficients of correlation between the several physical traits and also between certain of these traits and mental traits are given in Table XI. The variation in pulse rate for standing positions before and after jumping given in Table X was correlated with chronological age, resulting in a small positive coefficient. The coefficient of correlation with mental age is also small but slightly higher when chronological age is made constant. The variations due to muscular exercise are irregular but follow the expected trend, showing a rise after exercise followed by a prolonged fall. The range of absolute values of pulse rates shows wide individual variation both in actual increase and in the rate of return. The coefficient for systolic blood pressure and mental age is 0.417.±04, but this becomes .02±.07 when the factor of chronological age is eliminated. It is indicated that the mental traits as measured by the tests in the Stanford Revision of the Binet-Simon Scale are not directly related to absolute blood pressure readings.

Summary

The repeated measurements of weight, height, pulse rate, and blood pressure of the same children at regular intervals show wide variations from established norms for certain groups.

The trend of growth in height is similar to that shown by averages obtained from single measurements of large groups of children at each age. The norms for height established by Baldwin for tall girls are more closely approximated by the children in the present study than are the general norms that have been proposed. Some individual children vary from year to year by greater amounts than normal variations obtained on these large groups have indicated.

Consecutive measurements of the same children show marked individual variations from standards for weight that have been obtained from single measurements of large groups. The rate of growth in weight is clearly different for different individuals and fluctuations appear at varying ages. It is indicated that standards should be established for different types of build for the determination of the influence of hereditary factors upon the rate of growth. Such standards can be obtained only from repeated measurements of a sufficiently large number of the varying types.

The ratio of weight to height increases with chronological age, but small groups at each age show wide variations from the general trend.

As the weight and height increase and also as the ratio of the weight to the height increases, the blood pressure increases. The blood pressure is influenced to a greater extent by the Weight-Height Index than by chronological age.

Strength and rapidity of movement are directly related to the Weight-Height Index, the influence upon strength being the more significant.

The pulse rate decreases with increasing chronological age and with increasing Weight-Height Index. For a small group the influence of age seems greater than that of relative weight for height.

The acceleration in pulse rate with change of position from vertical to standing shows a slight tendency to increase with age.

There is a close correlation between chronological age and mental age, as is reported in Chapter IV, but the correlation is only a little less between chronological age and Weight-Height Index. The simple correlation of Weight-Height Index and mental age is also relatively high, but when the influence of chronological age is eliminated there is no tendency for mental age to increase with increasing weight for height.

There is no tendency toward increasing mental age with heightened blood pressure if the chronological age factor is eliminated.

CHAPTER III

GROWTH IN MUSCULAR CONTROL

Strength of the Hand—

A SMEDLEY dynamometer was used. The use of the instrument was illustrated to the child as follows:

"This instrument is to measure how strong your hand is. I take it in my hand this way (holding it down at side and not pushing against side) and then squeeze just as hard as I can. The harder I squeeze the farther those pointers move; and when I let go, one of them stays in place to show how hard I have squeezed. See? Now hold out your hand and you take hold."

In the beginning of the testing program the adjustment of the dynamometer was attempted in accordance with the measurements suggested by Whipple (27). We found this method as uncertain in practice as was an inspectional adjustment aimed to secure a hand position which would bring the inner stirrup against the base of the middle fingers. The latter method was used.

The instructions then given were:

"Remember you are to let go when you have squeezed as hard as you can; for one pointer will stay, to show me how strong your hand is. Now you take it, hold it down at your side and squeeze just as hard as you possibly can."

Three trials were given with each hand, alternating right and left. Each trial was recorded in kilograms. The average of the three trials for each hand was used for the analysis of the data.

The instrument is unsatisfactory for the young children. The breadth and thickness of the bars prevent the smaller children from getting a firm hold and probably cause a discomfort which handicaps the performance in succeeding trials. It is desirable with young children to emphasize to them the fact that it is not necessary to maintain the maximal grip in this

form of the test as they frequently tend to do. The face reddens, the grip lessens, and there is a tendency to take another grip and squeeze again, which can be prevented if the experimenter watches the dial of the dynamometer (which should be held outward from the body) and takes the reading without waiting for the child to extend the dynamometer.

Age Differences

The distribution of scores at each age from three and one-half to thirteen years for intervals of a half year are given in Tables XII and XIII. For those ages at which there is a sufficient number of cases to justify consideration of age differences there is an increase in score with increasing age by intervals of a year. The half-year intervals do not show consistent variations. This division not only reduces the number of cases for each age group, but in such a sampling, selected neither for sex nor age, we would expect this reduction to increase the probability of the obscuring of age-differences by other factors. Since boys have generally been found superior in this test the failure to have an equal number of each sex at each age group would be such a factor. The tendency in this group of girls and boys is to increase from 1.2 to 2 kilograms a year between the ages of six and ten years with both right and left hands.

The scores given in Table XIV for the smaller group of children who were retested at intervals of approximately a year show the increase with age, but at a slower rate than that indicated by the figures for the large group.

The correlation coefficient for Dynamometer, right hand score, and chronological age for 98 cases is $0.765 \pm .03$. This is reduced to $0.417 \pm .06$ when mental age is held constant and to $0.387 \pm .06$ when mental age and Weight-Height Index are held constant. This is but little more than the correlation coefficient of 0.356 ± 0.06 for Dynamometer and Weight-Height Index when mental and chronological age are held constant. The conflicting reports concerning the relation of strength to intelligence are probably due in great part to failure to consider the weight and stature relationship. The coefficient of correlation between Dynamometer Score and Mental Age (Stanford-Revision) is 0.712 ± 0.03 but when chronological age and Weight-Height In-

Table XII

DYNAMOMETER—RIGHT HAND, SCORE

SCORE IS ARITHMETIC MEAN OF SCORES FOR 3 GRIPS

Age.....	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13
Score																				
1																				
2																				
3	.....	.....	.....	.....	1															
4	.....	1																		
5	.....	.....	2	2	.....	2	4													
6	.....	.....	.....	4	1	1	1													
7	1	.....	.....	3	.....	4	2	1	1	1										
8	.....	.....	.....	1	1	.....	4	2	1											
9	.....	.....	1	.....	2	2	8	4	2	3	2									
10	.....	.....	.....	.....	1	4	4	4	7	2	3	2	1	.....	1					
11	.....	.....	.....	.....	.....	2	3	4	1	4	3									
12	.....	.....	.....	.....	.....	.....	.....	6	2	1	.....	3	2	6	.....	1				
13	.....	.....	.....	.....	.....	.....	.....	3	2	3	2	5	2	2	4	1				
14	.....	.....	.....	.....	.....	.....	.....	.....	1	3	3	2	7	9	5	1	1			
15	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	2	4	7	6	1	1			
16	.....	.....	.....	.....	.....	.....	.....	.....	1	2	2	1	.....	4	5	2	1			
17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	5	5					
18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	2	2	1	1			
19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	.....	2	1	.....	.....	.....	1
20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	.....	1	1	.....	.....	.....	1	
21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1					
22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1					
23																				
24																				
25																				
26																				
27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1								
Total.....	1	1	3	10	6	15	26	24	18	21	16	19	19	36	33	8	4	0	1	1=262
Average Score.	7	4.5	6.2	6.3	7.5	8.4	8.4	10.6	10.6	12.1	12.6	14.6	14.3	14.8	15.9	15.3	15.8	....	20.3	18.7
Standard Deviation...	.....	.....	1.8	0.7	2.1	2.1	1.8	1.6	2.1	2.5	3.0	3.9	2.0	1.9	2.5	2.1	1.2			

Table XIII

DYNAMOMETER—LEFT HAND SCORE

SCORE IS ARITHMETIC MEAN OF SCORES FOR 3 GRIPS

Age.....	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13
Score																				
1																				
2																				
3	.....	.....	.....	1	1	.....	1													
4	.....	.....	.....	1	.....	1	1													
5	1	.....	.....	4	1	1	1	1	.....	.....	.....	.....	.....	1						
6	.....	1	2	1	.....	2	4	.....	.....	1										
7	.....	.....	.....	2	3	1	4	.....	2	1	.....	1	.....	1						
8	.....	.....	1	1	.....	4	3	5	5	.....	1	.....	.....	1						
9	.....	.....	.....	.....	1	2	7	1	2	3	3									
10	.....	.....	.....	.....	.....	1	4	7	5	5	1	1	3	2						
11	.....	.....	.....	.....	.....	2	.....	1	2	3	4	1	4	5	3	2				
12	.....	.....	.....	.....	.....	1	1	6	1	2	1	3	3	4	5					
13	.....	.....	.....	.....	.....	.....	.....	3	.....	3	3	6	2	4	1	1	2			
14	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	1	2	3	2	4	3	1			
15	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	2	4	6	8					
16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	7	2	1	1			
17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	.....	1	3					
18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	3	1	.....	.....	1	1
19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2					
20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	1					
21																				
22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1					
23																				
24																				
Total.....	1	1	3	10	6	15	26	24	18	21	16	19	19	36	33	8	4	0	1	1=262
Average Score.	5.0	6.0	6.8	5.4	6.4	7.9	7.9	10.2	9.6	10.9	11.7	13.5	12.5	13.3	15.1	13.9	13.9	....	18.3	18.0
Standard Deviation...	.....	.....	1.1	1.4	1.9	2.2	2.2	1.9	1.9	2.2	2.4	3.2	1.8	3.1	2.7	2.0	1.1			

dex are constant it becomes 0.028±0.07. In a less homogeneous group in distribution of Intelligence Quotients a higher coefficient might be found. The age score we have obtained from retests of the same individual vary little from Smedley's norms for large groups, but are consistently less than the norms given by Dewey, Child, and Ruml (4) for 50 Hebrew children of each sex.

The Standard deviations for ages 6 to 10.5 years range from

Table XIV

DYNAMOMETER SCORE—DISTRIBUTION OF SCORES AT DIFFERENT AGES FOR 57 CASES HAVING RETESTS

SCORE IS ARITHMETIC MEAN OF 3 GRIPS

Score.....	1–2	3–4	5–6	7–8	9–10	11–12	13–14	15–16	17–18	19–20	Number of Cases	Average Score	Average Interval in Years
First Test:													
At 5:													
1st test R.	...	...	2	2	2	.....	.....	.....	.....	.....	6	7.6	0.9
1st test L.	1	1	2	2	.....	.....	.....	.....	.....	.....		5.9	
2d test R.	...	...	2	1	3	.....	.....	.....	.....	.....	6	8.4	
2d test L.	...	2	...	2	2	.....	.....	.....	.....	.....		7.0	
At 6													
1st test R.	...	...	...	1	10	1	.....	.....	.....	.....	12	9.7	0.9
1st test L.	...	...	...	5	7	.....	.....	.....	.....	.....		9.1	
2d test R.	...	...	...	1	9	2	.....	.....	.....	.....	12	10.1	
2d test L.	...	...	1	4	6	1	.....	.....	.....	.....		9.1	
At 7													
1st test R.	...	...	...	1	6	7	2	.....	.....	.....	16	11.1	1.0
1st test L.	...	...	1	3	5	6	1	.....	.....	.....		10.4	
2d test R.	...	...	1	...	5	4	1	5	.....	.....	16	12.2	
2d test L.	...	...	1	1	4	5	4	1	.....	.....		10.8	
At 8													
1st test R.	...	...	...	...	1	4	2	.....	.....	1	8	13.0	1.0
1st test L.	...	...	...	...	3	4	.....	1	.....	.....		11.7	
2d test R.	...	...	...	...	2	1	4	.....	1	.....	8	13.3	
2d test L.	...	...	...	1	2	1	4	.....	.....	.....		11.6	
At 9													
1st test R.	...	...	...	...	....	4	5	2	1	.....	12	13.7	0.8
1st test L.	...	...	...	...	1	6	4	1	.....	.....		12.5	
2d test R.	...	...	...	...	....	3	4	3	2	.....	12	14.7	
2d test L.	...	...	...	...	1	4	3	3	1	.....		13.7	
3d test R.	...	...	...	...	....	2	1	3	2	.....	8	15.4	1.0
3d test L.	...	...	...	...	....	1	4	2	1	.....		14.5	
At 10													
1st test R.	...	...	...	...	....	1	1	.....	.....	.....	2	13.1	1.2
1st test L.	...	...	...	...	....	2	.....	.....	.....	.....		11.4	
2d test R.	...	...	...	...	....	.....	1	1	.....	.....	2	14.4	
2d test L.	...	...	...	...	....	.....	2	.....	.....	.....		14.2	
At 11													
1st test R.	...	...	...	...	....	.....	.....	1	.....	.....	1	13.3	0.6
1st test L.	...	...	...	...	....	.....	1	.....	.....	.....		12.0	
2d test R.	...	...	...	...	....	.....	.....	1	.....	.....	1	14.3	
2d test L.	...	...	...	...	....	.....	1	.....	.....	.....		12.7	

1.8 to 3.9 kilograms. There is a slight tendency toward increase in variability with increasing age.

Right and Left-Handedness

Considering the average scores of three trials in one test, eight boys and eight girls showed superiority of the left hand on the first test. A year later only one of the boys and no girl made a higher score with the left hand; the other seven boys showed a superiority of the right hand and two of the girls had equal scores for right and left hands in this second test. One of these girls had a stronger left hand in the third test the next year and one of the eight girls who was left-handed in the second test again showed superiority of the left hand.

Analysis of the scores for each trial shows more clearly the lack of consistency in dextrality. Left-handedness in all three trials at one test was shown in one case and seventeen showed superiority of the left hand in two of the three trials. There were twenty-six who were consistently right-handed in one test but only one who was superior with the right hand in each of nine trials for three tests approximately a year apart. There were three children making the same score with each hand in the three trials of one test and twenty who made equal scores in two of the three trials. The distribution of scores for each trial, as given in Table XV, shows a marked tendency toward right-handedness, the frequency of equal scores exceeding that of superiority with left hand. The difference in averages for the two hands varies from 0.4 to 1.5 kilograms for the half-year

Table XV

DISTRIBUTION OF DYNAMOMETER SCORES FOR RIGHT AND LEFT HANDS

	Test I				Test II				Test III			
Trial.....	1	2	3	Total	1	2	3	Total	1	2	3	Total
Right superior....	64	64	76	204	42	33	32	107	8	9	8	25
Left superior.....	20	22	13	55	6	11	10	27	2	2	3	7
Equal score.....	28	26	33	87	9	8	15	32	1	..	..	1
Number of cases..	112	....	....	.....	57	....	....	.....	11			

intervals. Smedley (21) reports 0.6 to 0.9 kilogram for these ages at intervals of a year. Dewey, Child, and Ruml find right-hand superiority of 1.2 kilograms for ages nine and ten.

We find variability of individual performance greater than the difference in averages for the two hands for all ages. Retests show a tendency for the young child who has a stronger left hand to become ambidextrous or right-handed as he grows older.

Sex Differences

The number of each sex at the age of first testing is small and sex differences shown by the averages are not conclusive.

Table XVI

SEX DIFFERENCES IN DYNAMOMETER SCORES FOR RIGHT HAND

First Test	Girls			Boys		
	Number	Average Score	Range	Number	Average Score	Range
At 5 years:						
First	4	6.8	5.3– 8.7	2	9.2	9.0– 9.5
Second	4	7.7	5.0–10.8	2	9.8	8.7–10.7
At 6 years:						
First	6	9.4	8.7–10.8	6	9.7	9.0–11.0
Second	6	10.2	8.7–12.0	6	9.9	9.0–12.3
At 7 years:						
First	6	10.4	7.3–12.7	10	11.5	9.3–13.3
Second	6	10.6	6.7–15.7	10	13.1	9.0–16.3
At 8 years:						
First	4	13.2	9.3–20.3	4	12.9	11.3–14.3
Second	4	13.0	9.0–18.7	4	13.6	12.3–14.0
At 9 years:						
First	6	13.3	11.5–15.3	6	14.2	12.0–18.3
Second	6	14.1	12.7–16.7	6	15.4	11.7–18.0
	*3	12.6		5	15.2	
Third	3	13.9	12.0–15.00	5	16.3	12.7–18.7
Total	26	.....	.....	28		

* Average scores made by those individuals who were retested a year later.

The consistent superiority of the boys at each age and in successive tests is a more reliable indication of a real sex difference. This is shown in Table XVI, for twenty-six girls and twenty-eight boys who were first tested between the ages of five and nine. Boys excel girls by 1.5 kilograms on the average. This varies for the different ages as does the range of scores made by each sex. In some age groups, as at eight, the girls show much more variability, but the distribution of scores for all ages shows somewhat greater variability for the boys.

Taking the average score for the three trials at the first test of sixty-five boys and fifty-one girls the percentages of each sex making a given score were correlated. The coefficient found was 0.80±.03. In like manner the percentages of each sex at a given age in months were correlated and a coefficient of 0.39±.07 was obtained. It is indicated that the distributions are quite dissimilar in chronological age, which would account in part for the magnitude of the sex difference found but would only partially explain the differentiation in tendency to make the same dynamometer scores. Little sex difference is shown in the amount of gain from year to year.

Reliability

The reliability coefficient for the first and second tests for fifty-seven cases is 0.826±.05 which becomes 0.68±.05 when chronological age is held constant. For larger groups more homogeneous as to chronological age and sex the reliability would probably be high and in relation to Weight and Height Index would be suggestive of nutritional condition of organism.

Tapping Test—Alternate Plate—

The Dunlap (5) improved form of tapping plate was used. A kymographic record was made showing the number of taps on each plate and the time intervals in seconds registered by a Jacquet chronograph.

The child was instructed to hold the stylus in the right hand and to strike first upon one plate then upon the other just as rapidly as possible. The procedure was illustrated. Each child stood during the performance and by means of a wooden platform and tables of varying heights the plate was adjusted

according to the height of the child. When in position he was told to wait for the command—"Ready—Go," then to begin tapping and to continue until told to stop. At the end of thirty seconds as noted by a stop watch a rest of fifteen seconds was allowed and then another thirty second period of tapping was recorded. In evaluating the data the number of taps for each fifteen second interval has been used for the study of changes in rate and regularity of performance.

Age Differences

The analysis of the data as given in Table XVII shows the definite trend toward increase in rate with age from four to ten. This increase is shown both in the total number of taps recorded for one minute and in the subdivisions of fifteen seconds. The absolute increment varies, the greatest gain occurring between ages eight and nine. The variability within the age group is also greater for ages nine and ten than in the earlier years. The correlation coefficient for number of taps in one minute at first test and chronological age to time of testing is $0.637 \pm .049$. It is evident that other factors than chronological age play a considerable part in determining the efficiency in this test. In Table XVIII which shows the increase from one year to the next for retested individuals when grouped according to the chronological age at which the first test was given, there is shown a distinct improvement with age; but when the scores of those children who were five years old at the second test are compared with the scores of those who were five years old at their first test, the difference indicates marked practice effects. This effect is to be noted for other ages except that of seven. A special study of the effects of practice in this test was made with nine children, who tapped continuously for two minutes each day for nine days, the days being consecutive except for the interval of Saturday and Sunday. The record of average scores, plotted in Figure 6 by periods of thirty seconds, shows an increase from first to second test that is greater than the increase shown from year to year by the retested individuals.

Table XVII

TAPPING ALTERNATE PLATE SCORE

SCORE IS TOTAL NUMBER OF TAPS IN GIVEN TIME

Chronological Age, in Years and Months	First 15 Seconds			Second 15 Seconds			Third 15 Seconds			Fourth 15 Seconds			Total 1 Minute		
	Number of Cases	Average Score	Standard Deviation	Number of Cases	Average Score	Standard Deviation	Number of Cases	Average Score	Standard Deviation	Number of Cases	Average Score	Standard Deviation	Number of Cases	Average Score	Standard Deviation
yr. mo. yr. mo.															
3 6 to 3 11	1	28.0	.....	1	26.0										
4 0 to 4 5	12	26.1	9.1	7	22.7	7.5	6	27.7	10.2	6	24.2	6.4	12	99.6	25.9
4 6 to 4 11	12	29.3	7.4	12	25.8	7.0	11	25.8	6.4	11	25.1	6.4	20	110.8	19.8
5 0 to 5 5	18	34.9	9.5	18	29.7	6.9	18	31.2	10.2	18	29.8	6.8	24	121.6	29.2
5 6 to 5 11	24	37.8	7.5	24	35.4	6.7	24	35.7	7.8	24	33.3	7.4	33	134.6	30.7
6 0 to 6 5	19	39.8	11.3	19	36.1	9.3	18	34.3	8.3	18	35.2	9.2	30	136.9	31.2
6 6 to 6 11	21	44.9	14.2	21	36.9	10.0	20	42.5	13.1	20	35.6	9.8	48	141.1	32.3
7 0 to 7 5	20	45.0	14.0	20	38.3	8.9	20	45.4	13.3	20	39.1	11.1	26	158.2	40.2
7 6 to 7 11	12	48.0	15.1	12	42.8	12.7	12	45.5	16.0	12	41.6	14.2	16	163.2	51.8
8 0 to 8 5	21	52.8	10.5	21	44.5	7.1	21	52.6	9.6	21	44.2	9.0	21	194.1	27.9
8 6 to 8 11	16	54.1	13.8	16	48.7	8.8	16	56.9	12.3	16	50.3	9.9	17	208.0	41.2
9 0 to 9 5	19	83.3	30.5	19	70.4	23.6	18	82.1	28.3	18	68.3	19.5	18	301.9	99.6
9 6 to 9 11	14	90.1	35.7	14	74.5	24.3	13	86.3	32.5	13	68.3	24.7	13	315.7	114.5
10 0 to 10 5	13	79.5	28.3	13	74.3	28.2	12	82.2	28.6	12	76.2	27.8	12	312.6	113.5
10 6 to 10 11	6	82.3	24.8	6	71.0	21.1	5	70.8	26.2	5	63.6	22.7	5	276.4	90.0
11 0 to 11 5	8	62.6	18.9	8	54.1	14.4	8	57.4	14.3	8	53.0	8.9	8	227.1	53.9
11 6 to 11 11	4	69.0	3.9	4	56.5	7.1	4	71.0	10.3	4	62.3	8.4	4	258.8	23.5
12 0 to 12 5															
12 6 to 12 11	1	61.0	.....	1	42.0	.....	1	57.0	.....	1	36.0	.....	1	196.0	
13 0 to 13 5	1	93.0	.....	1	78.0	.....	1	82.0	.....	1	73.0	.....	1	326.0	
Total.....	242			237			228			228			309		

Table XVIII

TAPPING—ALTERNATE PLATE

DISTRIBUTION OF SCORES AT DIFFERENT AGES FOR ONE MINUTE PERIOD FOR 66 CASES HAVING RETESTS

Number of Taps.....	40–69	70–99	100–129	130–159	160–189	190–219	220–249	250–279	280–309	310–339	Number of Cases	Average Score	Average Interval in Years
First Test													
At 4													
1st test.	2	1	3	1	.....	.....	.....	.....	.....	.....	7	97.6	1.2
2d test.	....	1	2	3	.....	1	.....	.....	.....	.....	7	131.4	0.8
3d test.	....	....	.....	.....	.....	1	.....	.....	.....	.....	1	196.00	
At 5													
1st test.	1	3	2	2	1	.....	.....	.....	.....	.....	9	114.4	9.3
2d test.	....	1	3	2	2	1	.....	.....	.....	.....	9	143.0	1.0
3d test.	....	....	.....	.....	.....	2	.....	.....	.....	.....	2	202.3	
At 6													
1st test.	....	1	3	2	5	1	1	.....	.....	.....	13	155.8	1.3
2d test.	....	....	1	3	3	2	2	2	.....	.....	13	192.4	0.9
3d test.	....	....	.....	.....	.....	.....	2	1	.....	.....	3	241.3	
At 7													
1st test.	....	....	5	3	5	1	.....	1	.....	.....	15	151.9	1.0
2d test.	....	1	1	2	2	2	5	1	1	.....	15	197.1	1.1
3d test.	....	....	.....	.....	.....	1	.....	.....	.....	.....	1	196.0	
At 8													
1st test.	....	....	.....	.....	4	2	1	.....	.....	.....	7	190.6	1.0
2d test.	....	....	.....	.....	3	2	.....	1	1	.....	7	210.9	
At 9													
1st test.	....	....	1	.....	1	7	2	2	.....	.....	13	206.8	0.8
2d test.	....	....	.....	1	3	3	5	.....	.....	1	13	214.5	1.0
3d test.	....	....	.....	.....	.....	1	.....	2	2	1	6	272.2	
At 10													
1st test.	....	....	.....	1	.....	.....	.....	.....	.....	.....	1		
2d test.	....	....	.....	.....	.....	.....	1	.....	.....	.....	1		
At 11													
1st test.	....	....	.....	1	.....	.....	.....	.....	.....	.....	1		
2d test.	....	....	.....	.....	.....	.....	1	.....	.....	.....	1		

FATIGUE EFFECTS

As an index of fatigue the loss in numbers of taps in the last fifteen seconds as compared with the record in the first fifteen seconds was computed. The difference was expressed as a percentage both of the number of taps in the first fifteen seconds and of the total number of taps in the one minute period of testing. The validity of such measures for fatigue is not established. The co-operation of the child in putting forth his best effort throughout the test is one of many factors that may obscure the fatigue effects. As a measure of relative efficiency under conditions standardized as far as possible with regard to procedure and incentive, such measures seem worthy of analysis. We shall refer to these measures as Fatigue Index A,

which is loss referred to efficiency in first fifteen seconds, and Fatigue Index B, which is loss referred to total number of taps in one minute. These indices were calculated for forty-four children who were retested and for whom we had weight and height measures within two months of testing. The coefficient of correlation between the two indices at the time of the second testing is 0.965±.01. There is little reliability of the indices as determined by correlating the index at the first testing with the same type of index at the second testing a year later. The correlation coefficients for reliability are: Fatigue Index A, —0.217±.09, Fatigue Index B, —0.205±.09. These values would

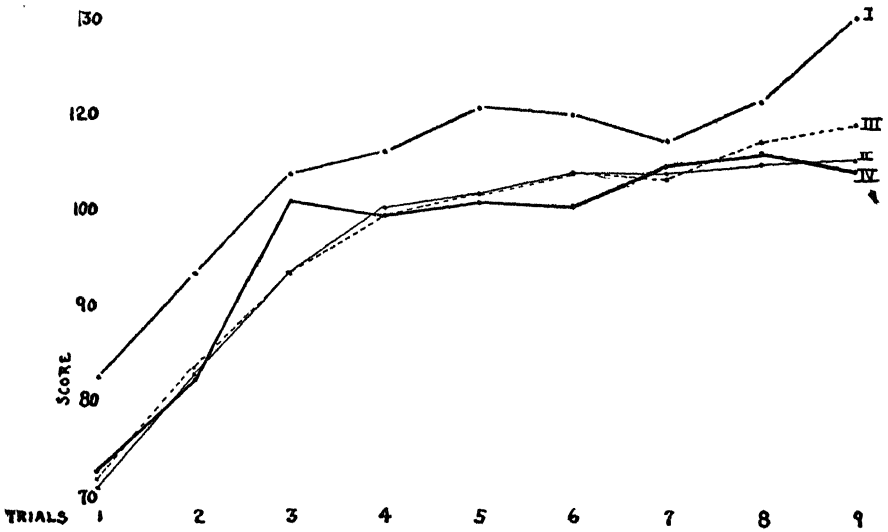

FIG. 6.—Practice effects in rate of tapping on alternates plates.

fall within the range of those that result from chance distributions. The graph (Figure 7) of age differences in average scores for each fifteen seconds shows a tendency toward decrease in second period, increase in the third and decrease again in the final period. At four and a half and at six there is more uniformity throughout the test. Consideration of the averages for the first thirty seconds and the last thirty seconds shows a range of differences for ages four to ten, from —5 to +10, these two extremes occurring in the ten-year group and in the nine-and-a-half-year group. The average difference for the 273 cases is 0.13 tap.

The variations in individual performance would contribute to the unreliability of such indices where a single day's reading

is taken. This irregularity is shown by the distribution of the maxima and minima of the individual scores in the different quartiles given in Table XIX.

While the majority followed the tendency noted in the averages, namely, making their maximum scores in the first and

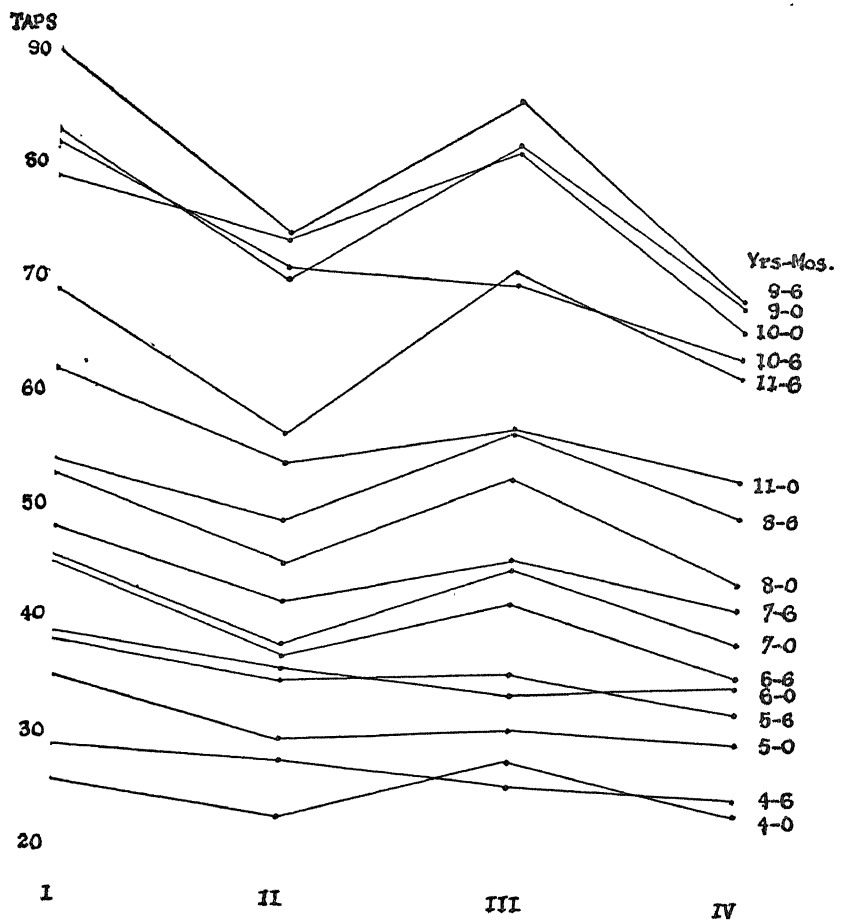

FIG. 7.—Age differences in rate of tapping on alternate plates. Averages for 15 second intervals are plotted.

third periods, and their minimum scores in the second and fourth periods, a fairly large per cent both of girls and of boys are variants: 33 per cent of each sex made their maximum scores in the second and fourth periods; while 23 per cent of the girls and 25 per cent of the boys made their minimum scores in the first and third periods.

The correlation coefficient for Fatigue Index B and chrono-

Table XIX

DISTRIBUTION OF MAXIMAL AND MINIMAL SCORES IN TAPPING

	Girls—26				Boys—18			
15 Second Periods.....	1	2	3	4	1	2	3	4
Maximum Score:								
First test.....	7	4	12	3	6	3	8	1
Second test.....	9	4	10	3	7	0	8	3
Total.....	16	8	22	6	13	3	16	4
Minimum Score:								
First test.....	3	19	3	1	4	5	0	9
Second test.....	3	9	3	11	2	5	3	8
Total.....	6	28	6	12	6	10	3	17

logical age is $-0.135 \pm .099$. The sampling does not justify a conclusion as to the effect of age upon this loss in efficiency, but for this group there is no definite relationship shown. For Index B and the Weight-Height Index, with chronological age constant, a coefficient of $0.28 \pm .093$ was obtained. The influence of the Weight-Height Index upon the rate of hand movement is not nearly so great as upon strength of hand.

The temperamental traits which are difficult to measure undoubtedly play an important part in determining efficiency in this test.

Irregularity of Performance

If the instructions given in this test are followed strictly the same number of taps for each plate should be recorded. In dividing the one-minute record into four sections a variation of one tap might occur. This would allow a difference of four as a maximum for which method of scoring would account. Wide variations are found in the actual performance. Some individuals show a tendency to favor one plate, consistently registering more on that plate in each phase of the test; others favor sometimes one and then another; a third group equalizes the distribution throughout the test. Detailed study of right-hand records of a few children indicates a tendency in some individuals to maintain equality of distribution of taps on the

two plates, both in continuous tapping for two minutes and in successive tests of the same length with one-minute intervals between tests. Other children may show no irregularity in first

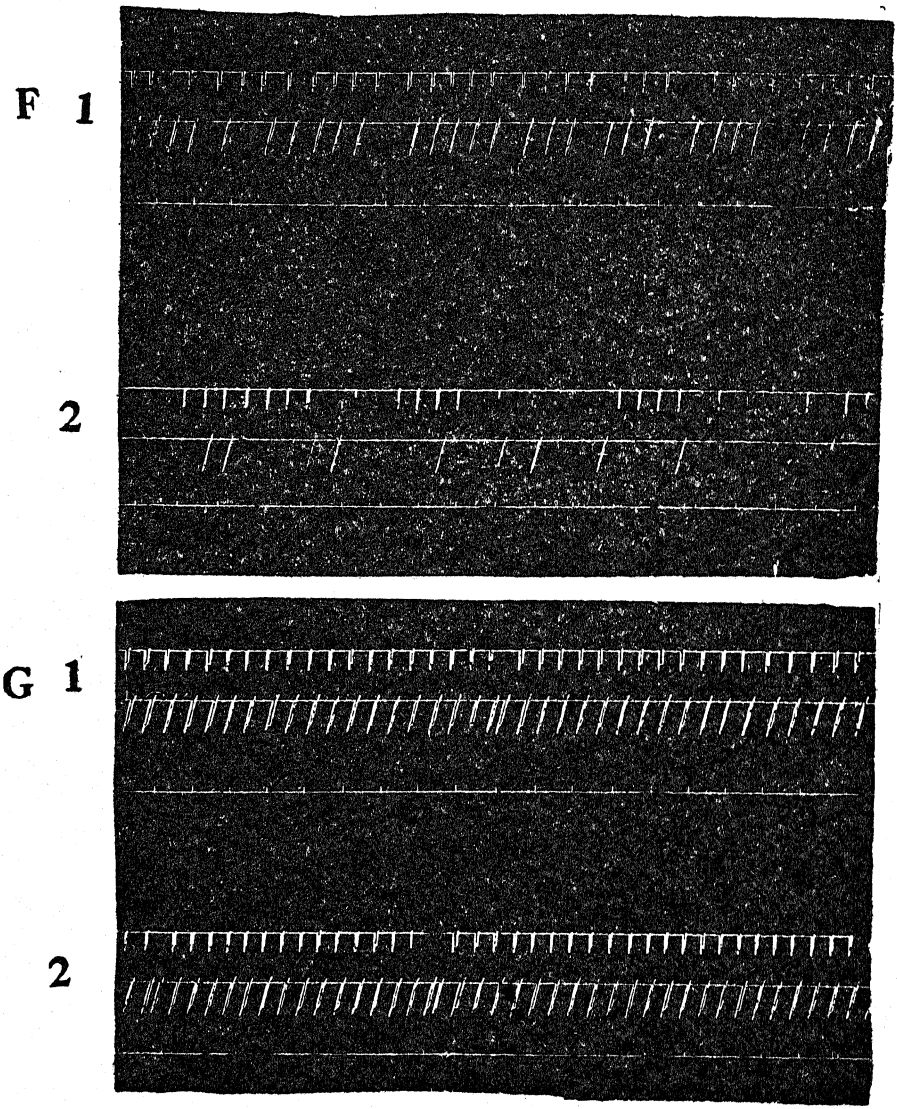

FIG. 8.—Kymographic records of tapping by boys F and G. Records for each plate are shown for two trials.

test but marked lack of control in the second or third test. The kymographic records of two boys representative of the two types are shown in Figure 8. In Figure 9 the number of contacts made on the two plates are plotted for ten-second intervals.

The two boys F and G for whom the differences in regularity of co-ordinated movements are illustrated in Figures 8 and 9

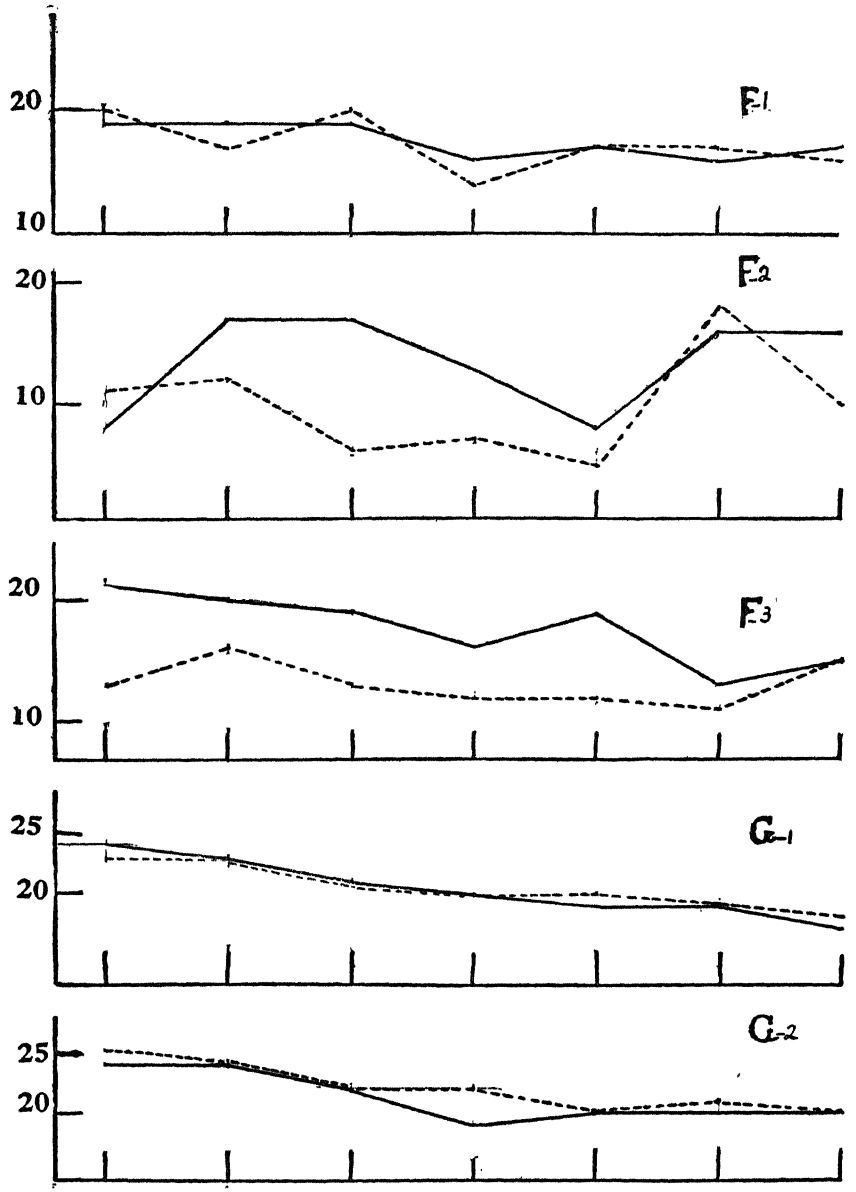

FIG. 9.—Number of contacts made in tapping on each plate by boys F and G for 10 second intervals.

vary widely in other traits. In steadiness or precision of motor control F is again irregular in performance. At seven he succeeded only in the first hole in the steadiness test while at nine

he was successful in the eighth hole, and at ten he failed to go beyond the fourth hole. G reached the fourth hole at nine and did not succeed in going beyond that in later tests. F excels G in strength of grip, but varies widely in successive performances.

At eight years of age they have a similar rating by the Stanford Revision of average mental ability, but G increases 20 points in his Intelligence Quotient from eight to ten, thus being classed finally as superior while F remains practically constant, varying one point then three points in successive examinations. In the performance scale tests F excels. At six he had a median age score of nine, and at nine and ten he had reached the limits of the scale, median age of 14 years, while G tested only 12 years both at age nine and at age ten.

In height, F gained 8.8 inches from age six and one-half years to age ten and one-quarter years; in weight, he gained 21.9 pounds. G gained 4 inches in height from age 8 years 7 months to age 10 years 10 months; in weight, he gained 11.9 pounds. From nine to ten each gained 2.1 inches in height and F gained 3 pounds in weight while G gained 4 pounds.

The behavior of the two boys in the school activities shows a marked difference in emotional tendencies. G was at times seemingly excitable and easy to cry over difficulties, but this appeared to be a habit developed because it worked in gaining his ends. He was a subject for a series of tests, the conditions of the experiment requiring a sample of blood before and after the testing. He drew back and cried when asked to put out his hand for the puncture, but when told he might withdraw and not take part in the experiment, he immediately subsided and went through with all requirements. Reports from the home stated that he had always been afraid of pain. This behavior seems rather an habitual reaction against the endurance of even slight pain and not undue excitation. Since that time he has shown improvement in such types of control.

F reacts violently to certain stimuli. When very young loud noises and machinery, especially in closed and darkened spaces, terrified him. The pupils of his eyes, ordinarily dilated, became more widely dilated, a greenish pallor overspread his face, and his body trembled. This trembling of the body was also observed at physical examinations and in gymnastics, as somersaults. At ages six and nine the knee-jerk and ankle-reflexes

were hyperactive. At intermediate ages the reflexes were just present or active. Pulse rate and blood pressure readings approximate the averages for his age and sex. An exception is the pulse rate at ten which falls eight points after jumping, while at other ages the rate increased from twenty to thirty-six points. He had great difficulty in adapting himself to the school group, at first taking little part in the general play activities of his group. During the transition stage he was inco-ordinated and at times antagonistic and aggressive, but he has finally emerged into a fairly well-adapted member of the group.

Facility in verbal responses was doubtless prevented by these emotional reactions which also interfered with regularity of performance in co-ordinated movements. It is also probable that his general organic state was such that disintegration occurred at an earlier stage than is usual in performances that required repetition of the same acts in immediate succession or the inhibition of certain reactions during a given period of time.

The absolute variations in registration for the two plates were computed for twenty-eight girls and thirty-two boys who were retested. The ages at which the first test was given ranged from four to nine, and valid age differences could not be obtained. There was no definite relationship shown either between irregularity of performance at various ages or in the two sexes.

Sex Differences

Consideration of the average scores made by girls and boys at each age at the time of the first test shows a superiority of the girls at each age except that of four. This difference occurs not only at first testing but in retests a year apart. The averages for thirty-one girls and thirty-three boys who were retested are given in Table XX. The individual differences in performances a year apart range from zero to twenty-two, both for girls and boys; but the average difference for girls is 7.2 taps; for boys 4.8 taps.

Greater variability in absolute scores is shown by the boys. The range of scores for boys at first testing is from 44 taps made by a child four years old to 250 taps made by one nine years old; for girls 62 taps by a child five years old to 254 taps by one seven years old. At the second testing the boys ranged from 90 to 271 taps; the girls, from 116 to 288 taps. The lower

Table XX

SEX DIFFERENCES IN TAPPING—ALTERNATE PLATE

	Test I				Test II			
	Girls		Boys		Girls		Boys	
	Number of Cases	Average Score	Number of Cases	Average Score	Number of Cases	Average Score	Number of Cases	Average Score
First Test:								
At Four.....	3	95.0	4	99.5	3	131.0	4	131.7
Five.....	6	121.8	3	99.6	6	150.7	3	127.6
Six.....	7	161.5	6	149.0	7	201.4	6	181.8
Seven.....	6	169.0	9	140.4	6	217.0	9	183.8
Eight.....	4	197.0	3	148.6	4	232.2	3	182.3
Nine.....	5	212.8	8	204.2	5	216.4	8	213.2
Total.....	31	.....	33					

limit was made at five and the upper at eight for both sexes. The variability does not seem to be due to sex so much as to sampling.

The fluctuations in individual scores from year to year fell within the same limits for boys and girls, though the average fluctuation for the girls was greater than for the boys. The girls show a higher fatigue index at each age except at nine at second testing. There were six girls and five boys at the first testing, four girls and four boys at the second testing who made better scores in the fourth fifteen seconds of tapping than in the first. In no case were they the same children at each test who showed these negative indices.

The girls are more irregular in performance as measured by the variation in registrations for the two plates. The differences range from zero to twenty-two both for girls and boys but the average difference for girls is 7.2 taps; for boys, 4.8 taps.

Reliability

The number of taps in one minute at the first test was correlated with the similar score made a year later for sixty-six children. The reliability coefficient is $0.63 \pm .049$, and with chronological age constant, this becomes $0.453 \pm .065$. The

analysis of differences between records for the two plates indicates that the reactions made are not the same in all cases. Observations of the experimenters include statements that in some cases movement was not sufficient to make contact though the child seemed to think he was touching each plate and that dividing board was scraped in passage. It is evident that the scope of movement varies for individuals. It is probable that the movements more nearly approached uniformity than the record indicates, since the child who thought he had made the contact failed to make any registration of that movement. Some attachment that would indicate to the child which contact is made might increase reliability.

Steadiness of Motor Control—

The materials used consisted of the steadiness tester described by Whipple (27) in Test 13, stop-watch, telephone receivers, and dry cells. Kymographic records were made in some cases, but they were not used throughout the study, while the telephone receiver was, and the data reported are based upon records determined by the count of clicks made in the telephone receiver. The study of the two methods by Holsopple (8) shows that the record of an observer using a telephone receiver will be practically the same as the kymographic record when the contacts are few. His records indicate that less than twelve contacts in a hole can be recorded by observer with a high degree of accuracy. There is a tendency in some children to sway backward and forward, thus bringing the needle out of the hole at times. For a careful study of steadiness in young children it is desirable to make a kymographic record of contacts and time intervals, leaving the observer free to note the position and movements of the child.

The method used followed that described by Whipple, except that we required the child to stand but still to hold the needle in such a way that the forearm formed an angle of approximately 100° with his upper arm. Adjustments for individual heights were made by means of a wooden platform upon which the smaller children stood. In the beginning of the testing program, each child was tested for each hole until he reached that hole in which he made more than twelve contacts. During the last three years the children eight years old and older began with the third hole. Assistance was given the child to

secure correct position with the needle put into the hole at right angles, not resting against the side of the whole, and extending through the hole with the caution not to let it come out during the trial. The standing position could be better adjusted to prevent contact of arm and body. Use of the instrument was illustrated and the child was allowed to hear the clicks in the sounder. He took delight in making the sounds during this explanation of how it worked, but emphasis was laid upon the fact that he was to keep from making sounds while the examiner was listening. The child was not informed as to the number of contacts made and he was assured that the contacts made in getting the needle into position did not count. The clicks made during the first three seconds of the eighteen seconds given to a hole were not counted. The total time for which contacts were counted was fifteen seconds for each hole that was attempted. The right hand was used for the continued study and the data reported are based upon right-hand records. Left-hand records were frequently made for individual diagnosis.

The number of contacts in each hole at each trial was recorded. In evaluating the data for age differences, the hole reached with twelve or less contacts was used as the score. The value for this score was also computed in accordance with the method used by Dewey, Child, and Ruml (4), and both scores are shown in the frequency table. In Table XXII showing repeated measurements, the distribution of contacts for each hole is shown.

Age Differences

The results in Table XXI indicate that between the ages of five years and ten and a half years, where numbers are sufficient to consider age differences shown, the hole reached varies by wide age intervals and that the measure is not fine enough to show age progression. The number of contacts related to the hole reached does not give a true picture of age differences, since the wider range of holes used increases and hence the average number of contacts is likely to increase, as, for example, between age five with average score hole 2, contacts 1.3, and age six and a half with average score hole 2, contacts 7.2. Under the conditions set by the testing procedure there is evident a slight tendency to increase in steadiness with chronogical age for the 366 children studied. The use of a certain number of

Table XXI

STEADINESS TEST SCORE

Age		3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	
Hole-Contacts	Score																					
IX	1																					
1- 6	2- 7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1										
7-12	8- 13																					
VIII	14																					
1- 6	15- 20																					
7-12	21- 26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1							
VII	27																					
1- 6	28- 33																					
7-12	34- 39	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	1	3						
VI	40																					
1- 6	41- 46	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	2	1						
7-12	47- 52	.....	.....	.....	.....	.....	1	.....	.....	1	1	.....	1	.....	9	8						
V	53																					
1- 6	54- 59	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1					
7-12	60- 65	.....	.....	.....	.....	.....	.....	.....	1	3	2	2	3	4	3	4	2	.....	.....	1		
IV	66																					
1- 6	67- 72	.....	.....	.....	.....	.....	.....	.....	1	1	4	2	.....	3	2	.....	2					
7-12	73- 78	.....	.....	.....	3	.....	1	8	8	2	5	4	4	4	2	5	1	1				
III	79	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1							
1- 6	80- 85	.....	1	.....	1	3	3	2	4	2	.....	1	.....	1	1	1	1	1	.....			
7-12	86- 91	.....	2	5	6	3	6	5	10	3	6	5	9	2	4	3	.....	2	.....	.....	1	
II	92																					
1- 6	93- 98	1	1	1	1	2	.....	6	1	1	1	1	.....	1	3	.....	1					
7-12	99-104	1	.....	.....	6	6	6	12	1	7	3	1	1	.....	2	5						
I	105	.....	.....	1	.....	1	1	2	.....	1	.....	.....	.....	1								
1- 6	106-111	.....	1	1	2	4	9	18	2	2	.....	.....	1	1								
7-12	112-117	.....	.....	1	.....	1	2	6	2	.....	.....	.....	.....	.....	2	4						
	118	.....	3	1	.....	.....	1	2	1	.....	.....	.....	.....	.....	1							
Total		2	8	10	19	21	30	62	31	23	23	17	20	18	34	34	8	4	0	1	1=366	
Average Hole		2	2	2	2	2	2	2	3	3	3	4	4	4	4	4	4	3	.....	5	3	
Average Contact		8.5	10.4	6.3	1.3	5.4	5.8	7.2	8.7	9.0	0	9.9	12.8	11.1	5.9	7.5	6.8	4.5	.....	8.0	11.0	
Average Score		100.5	102.4	98.3	93.3	97.4	97.8	99.2	87.7	88.0	78.9	75.9	78.8	77.1	71.9	73.5	72.8	83.5	.....	61.0	90.0	
Standard Deviation		3.5	13.8	13.4	9.9	10.2	14.4	14.6	13.6	17.3	13.8	20.6	78.3	15.9	24.9	25.1	11.7	5.2				

Table XXII

STEADINESS, CONTACTS

Distribution of Number of Contacts in Each Hole for Repeated Measurements at Different Ages

Hole-Contacts	First Test									Number of Cases	Average Interval in Years	Second Test									Number of Cases	Average Interval in Years	Third Test									Number of Cases	Average Interval in Years
	1	2	3	4	5	6	7	8	9			1	2	3	4	5	6	7	8	9			1	2	3	4	5	6	7	8	9		
First Test at—																																	
four										7	0.9										7												
0	2											4		1																			
1– 6	2	2										3	5	3																			
7–12	1	1	2										2	1	1																		
13–18	2		1	2										2	3																		
19+		2													1	1																	
five										10	1.7										10	1.1										1	
0	4	4										7	2										1										
1– 6	4	1	2									3	8	4										1									
7–12	1	2	3	1										3	2										1								
13–18	1	3	2	2	1									3	5											1							
19+			1	2												2																	
six										18	1.3										18	0.8										4	
0	8	3										14	7																				
1– 6	9	9	3	1								4	7	12	6								3	2	2								
7–12		4	6	2	1								4	3	6	3	1						1	1	2	1	1						
13–18	1	1	6	3	2	1								3	3	4	2	1						1		1	1						
19+				3	1										3	4																	
seven										16	1.2										16	1.4										3	
0	8	2										14	11	4	1	1	1							3	2								
1– 6	7	11	6	1								1	2	8	8	2	1		1					1	3	3							
7–12	1	1	7	6	1							1	3	4	3	2	1	2	2								1						
13–18		1	1	5	3	1									2	6											1						
19+			2	1	3										2	1	1	1	1								1	1					
eight										8	1.1										8	1.2										2	
0	5	1	1	1								8	2	1									2										
1– 6	2	5	3	2		1							6	4	3									1	1								
7–12		2	1		1									2	3	2								1		1							
13–18			1	2	2	1	1							1		3	2								1	1	1						
19+			2												1	1																	
nine										9	0.9										9	1.1										5	
0	7	1										9	3	1									5	1									
1– 6	2	4	3										4	4	1									4	2	1							
7–12		4	5	3	1								2	3	3	1	1								3	1							
13–18			1	4	2	1								1	3	3		1								3	2	1					
19+				1	1	1									2	1											1						
Total	67	64	59	42	19	6	1			68		68	68	68	63	37	10	5	2	2	68		15	15	15	14	9	3				15	
Average number contacts at—																																	
four	6.0	10.3	10.7	14.0								0.6	4.4	8.1	12.5	26.0																	
five	3.2	5.9	10.3	16.6								0.8	2.4	8.5	14.9	27.5																	
six	2.4	5.5	10.8	14.0	16.0							0.4	3.2	6.3	10.6	14.0	12.3	16.0					0.4	4.3	7.3	14.3	19.0						
seven	1.9	4.6	8.7	10.7	16.4							0.8	2.4	3.9	8.1	11.8	11.0	13.0	9.5	13.0			0	0.6	3.0	6.7	24.3						
eight	1.1	3.8	9.9	7.6	12.3							0	2.0	6.4	8.1	14.2	17.5						0	5.5	9.5	10.5							
nine	0.6	4.4	7.7	13.9	14.7	20.5						0	3.0	7.4	14.3	15.4	7.0	15.0					0	2.8	6.8	11.4	17.3						

holes for each child and the record of total contacts for all holes would, doubtless, have been a better procedure. The discouragement to a young child in attempting the small holes necessary for the older children would probably be less disadvantageous than the arbitrary limitations that have been set. The age scores given by Dewey, Child, and Ruml (4) also show irregularities which indicate the desirability of varying the testing procedure.

While the inequality in number of holes used still limits the analysis, a much clearer picture of age differences is given in Table XXII. The decreasing number of contacts made in each hole with increasing chronological age is shown in the first test, with a few exceptions for which the small numbers at each age might account. At the second testing approximately a year later, however, these same children show less tendency to vary with age. This lack of direct relationship to age is again evident in the performance of those children who were given a third test the following year. It is indicated that practice is the more significant factor in the determination of efficiency. A comparison of the scores made at five years of age by those children who were tested when four with the scores of the children who were five years old at the first testing shows a marked superiority of the former. This difference is noted in all cases where the number at the given age and test warrant any comparison.

The correlation coefficient for chronological age and steadiness score determined by finding the sum of the contacts made in holes one, two, and three at the second testing of sixty-eight children is $0.133 \pm .08$. This indicates the slight relationship which was noted in the average scores.

There is little relationship between the Weight-Height Index and this steadiness score as shown by the coefficient of $0.06 \pm .082$, which was obtained for the sixty-eight cases retested. This becomes a negative coefficient of $-0.36 \pm .082$, when chronological age is a constant value.

Sex Differences

The averages of contacts in each hole at each age for thirty-three boys and thirty-five girls who were retested are shown in Table XXIII. The score suggested by Holsopple as a fair index of steadiness is also shown. This score is a rating which

Table XXIII

SEX DIFFERENCES IN STEADINESS

Age	Number of Cases	Average of Contacts in Each Hole—Girls									Holsopple Score
		1	2	3	4	5	6	7	8	9	
Four	5	5.2	11.0	10.0	13.0	....	....	....	....	....	1.6
Five	7	1.6	4.7	11.5	17.0	15.0	....	....	....	....	2.4
Six	10	2.6	5.1	9.9	14.6	18.3	....	....	....	....	2.4
Seven	4	2.3	3.0	5.5	10.5	14.7	17.0	....	....	....	3.3
Eight	4	2.0	3.0	9.5	7.3	15.0	....	....	....	....	3.3
Nine	5	0.4	3.6	7.0	14.8	17.5	....	....	....	....	2.8
Number of cases	35	....	33	29	22	11	1				
Group average	.....	2.4	4.8	9.1	13.3	16.2	17.0				
Retest											
Five	5	0.2	3.0	5.8	12.5	26.0	....	....	....	....	3.0
Six	7	0.6	2.3	9.1	16.2	....	....	....	....	....	2.7
Seven	10	0.5	3.5	6.7	10.5	15.8	12.5	16.0	....	....	3.4
Eight	4	2.5	2.5	4.8	8.0	13.0	15.0	....	....	....	3.3
Nine	4	0	1.8	8.3	7.3	17.0	....	....	....	....	3.3
Ten	5	0	4.4	9.4	14.2	14.5	....	....	....	....	2.8
Number of cases	35	....	....	....	30	13	3	1			
Group average	.....	0.6	3.0	6.7	11.7	16.0	16.0	16.0			

Age	Number of Cases	Average of Contacts in Each Hole—Boys									Holsopple Score
		1	2	3	4	5	6	7	8	9	
Four	2	8.0	8.0	12.0	15.0	....	....	....	....	....	1.5
Five	3	7.0	8.7	3.0	15.0	....	....	....	....	....	1.3
Six	8	2.1	6.0	11.3	13.3	9.0	13.0	....	....	....	2.4
Seven	12	1.8	5.2	9.7	12.4	17.8	....	....	....	....	2.8
Eight	4	0	4.5	10.3	8.0	7.0	15.0	....	....	....	3.0
Nine	4	0.5	5.5	8.5	12.3	12.0	20.5	....	....	....	2.8
Number of cases	33	....	31	29	19	8	4				
Group average	.....	2.3	5.6	9.8	12.4	13.9	17.3				
Retest											
Five	2	1.5	8.0	14.0	....	....	....	....	....	....	2.5
Six	3	1.3	2.7	10.0	12.5	22.5	....	....	....	....	2.7
Seven	8	0.3	2.9	5.8	9.1	15.8	14.0	....	....	....	3.4
Eight	12	0.2	2.4	3.7	8.1	11.4	10.1	13.0	9.5	13.0	4.0
Nine	4	0	2.3	4.5	8.8	11.3	17.5	....	....	....	3.8
Ten	4	0	1.3	5.0	14.5	16.0	7.0	15.0	....	....	3.5
Number of cases	33	....	....	....	29	22	9	4	2	2	
Group average	.....	0.3	2.7	5.6	9.6	4.5	11.9	13.5	9.5	13.0	

allows fifteen contacts as a maximum total number of contacts, and the last hole before this limit is reached is the recorded score. The records obtained within the limits of the testing procedure were complete for such evaluation. With reference to the Holsopple scores, the sex differences shown in the first test are slight. The girls consistently make scores that are equal or superior to those of the boys. In the second test a year later the boys make scores that equal or exceed those made by the girls except at age five. If we consider the average number of contacts in each hole at each age, we find no consistent sex difference. The group averages for the first test show a superiority of the girls in holes one, two, and three; for the boys in holes four, five, and six, where number of cases is smaller. The group averages for the second test show a consistent superiority of the boys. Girls were found superior in steadiness at ages nine to thirteen by Dewey, Child, and Ruml (4), and at ages fourteen and fifteen by Woolley and Fischer (29). The sex differences shown were not constant, ranging from a difference for right hand of 15.1 in mean at nine years of age to 2.2 in mean at twelve years of age. Combining the values for fifty percentile rating given by Woolley and Fischer into the value used by Dewey, Child, and Ruml, we find a sex difference at fourteen years of age of 3, and at fifteen of 8, in favor of the girls. These results indicate a superiority of girls, after the age of nine.

Our results for younger children who have been subjected to a school environment from an early age, which encourages the same types of activities for both sexes, do not show significant sex differences. The establishment of distinct sex differences seems to depend upon repetition of tests and upon more refined methods of recording and evaluating results. So many factors are held to affect the movement of the hand in this test, such as position of body, respiration, physiological condition, and direction of attention, that one test conducted according to the standards we have used seems hardly indicative of the individual control. Analysis of the different methods of scoring indicates the value of a uniform procedure and of more exact records.

Target Test—

The target board and darts described by the writer (11) were used. The board could be adjusted to the height of the

child and this adjustment was such that when the arm of the reactor was extended straight forward from the right shoulder, it was in line with the bull's-eye. When the left hand throw was made the left arm was in line with the bull's-eye. The child stood at a distance of ten feet in the tests for which results are reported. During the first year of the work with the young children, the distance from the board at which the child should stand was the problem of most importance. Distances varying from three to ten feet were tried out. The child three or four

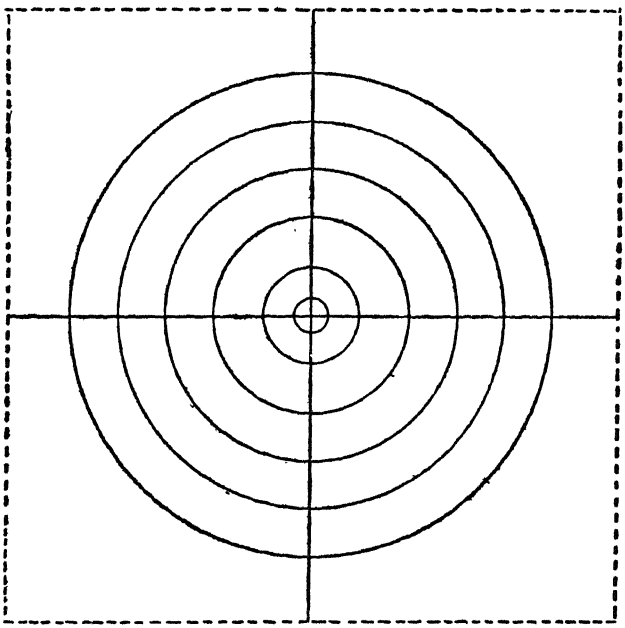

FIG. 10.—Target board, one-twelfth actual size. Taken from Bates, R. L. *The effects of cigar and cigarette smoking on certain psychological and physiological functions.* Jour. Comp. Psychol., 1922, vol. ii, no. 5, p. 52.

years old only occasionally succeeded in striking the board at a distance of ten feet. His performance was little better when seven feet away. Failing to make his darts strike in the board, he would step up closer, or sometimes keep his feet still and lean forward until he lost his balance. The young child could scarcely refrain from walking so close to the board that he could strike it. This was observed up to the age of six. Varying distances for each age seem desirable. A sufficient number of cases have not yet been tested for different distances to determine standards. The distance of ten feet was continued

for comparative results. No records are included of those who did not conform to the conditions and with whom we were experimenting upon this problem of distance.

The right and left arms were used during the first two years. The left arm was not continued and no data are given for left arm throws. The cases studied indicate greater reliability as to left-handedness in target test than in dynamometer or tapping. The overhand throw was used, and there was no tendency shown to use any other form. The pressure in grasp, the force and direction of throw were undoubtedly variants in individual performances.

Ten darts were thrown in a test. The darts were held in the left hand and removed one at a time. The interval between throws varied as the individual's rate of grasping and throwing the successive darts. Time records were not kept.

The values one, three, five, seven, and nine were given to the zones upon the board, beginning with the outer zone. When the dart entered the bull's-eye, a score of nine was given. When the dart failed to strike the target, a score of zero was given, regardless of the distance from the target at which it struck. The score recorded was the sum of the values for the ten throws. For statistical analysis, the average value of a throw was used as score.

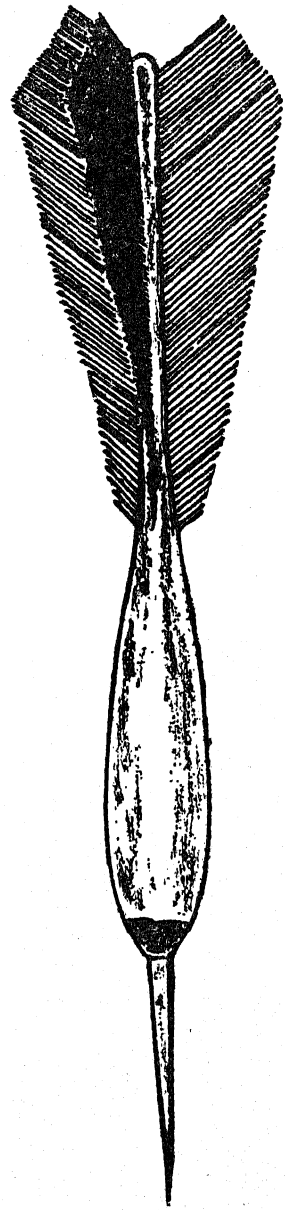

FIG. 11.—Dart, full size. Taken from Bates. Op. cit., p. 53.

AGE DIFFERENCES

The results given in Table XXIV show an increasing score from ages four to ten. The variability at each age is relatively

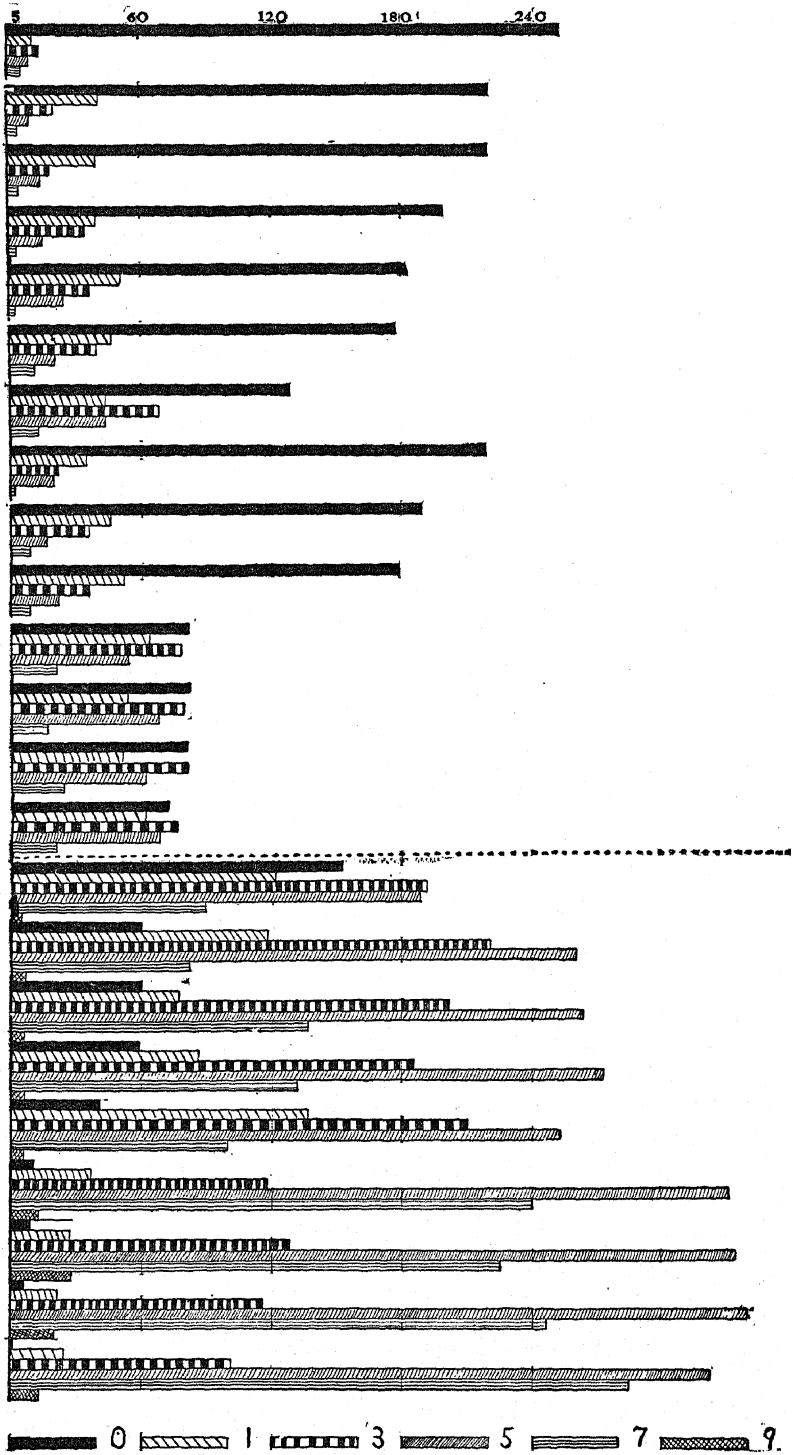

FIG. 12.—Distribution of values scored in target test.

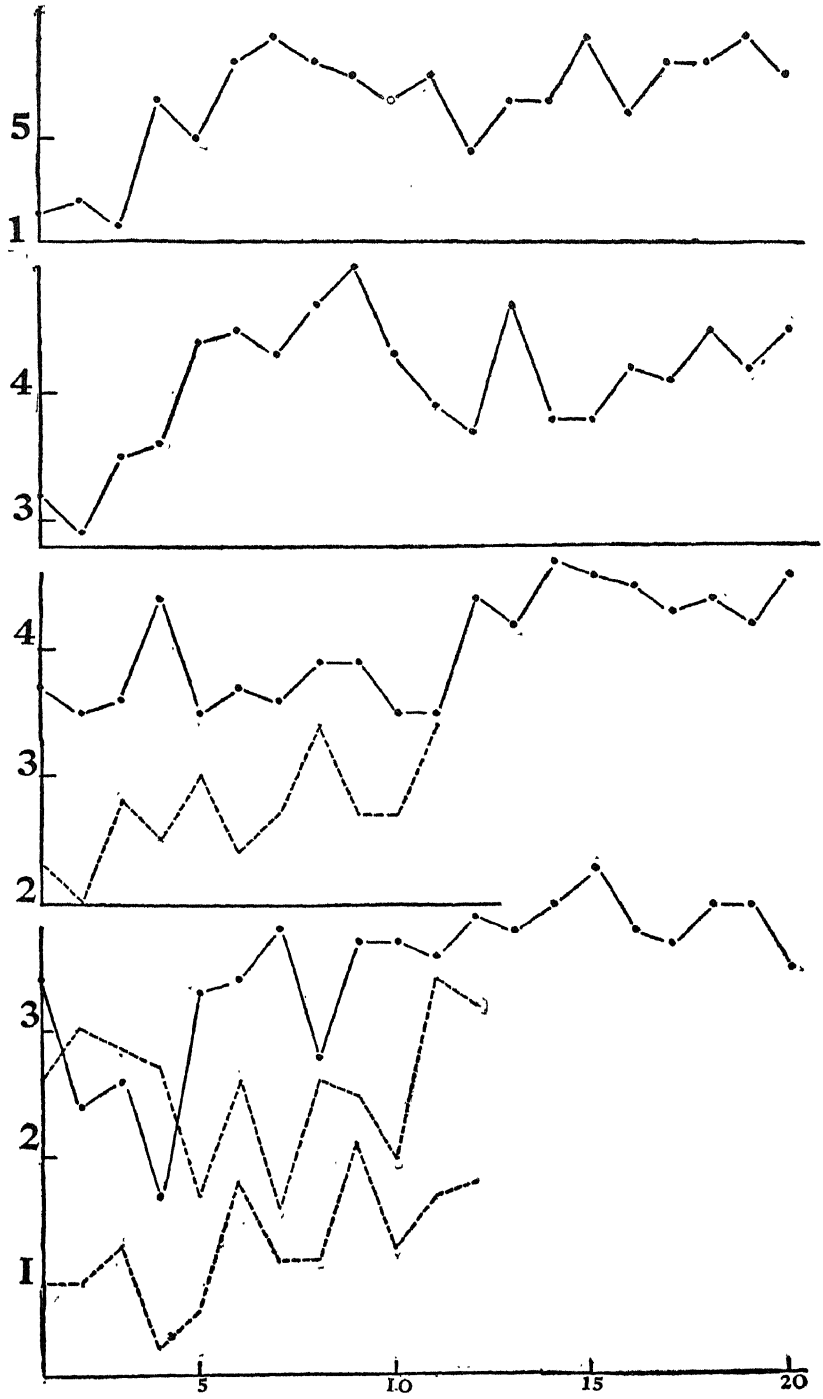

FIG. 13.—Practice curves in target test. Dotted line represents scores of children; continuous line, adults.

large. A practice series was given to six boys and eight girls between eight and ten years of age. A practice period consisted of thirty throws in groups of ten each, and one period was given each day with the exception of Saturdays and Sundays. The practice was given to all for ten days and to a few from eleven to fourteen days. There were wide fluctuations from day to day, but a general tendency to improve with practice was shown by some children. Others made little improvement for days, and in some cases lower scores were made at the middle of the series than in the initial stage of practice. The initial efficiency determines to an extent the amount of improvement shown. In Figure 13 daily scores are plotted to illustrate these types and the same types are shown for adults. The adults had a longer practice series, throwing seventy-five darts each day in groups of twenty-five. The distribution of values scored at each throw and of individual averages for all throws for adults and children are shown in Table XXV. Zero scores predominate for the children and the bull's-eye was rarely struck. The difference between the lowest score made by an adult and the best score

Table XXIV

TARGET TEST SCORE—DISTRIBUTION OF SCORES FOR DIFFERENT AGE GROUPS

SCORE IS ARITHMETIC MEAN OF SCORES FOR 10 THROWS

Age	3	4	5	6	7	8	9	10
Score								
0–0.4	.....	3	.....	10	2	2	1	1
0.5–0.9	.....	4	3	9	2	1	1	
1.0–1.4	1	1	2	10	5	2	3	
1.5–1.9	.....	.....	.....	10	3	1	2	
2.0–2.4	.....	1	.....	4	1	2	2	
2.5–2.9	.....	.....	.....	4	4	1	1	
3.0–3.4	.....	.....	.....	3	2	5	2	
3.5–3.9	.....	.....	.....	2	2	.....	2	
4.0–4.4	.....	.....	.....	.....	.....	.....	2	
4.5–4.9	.....	.....	.....	.....	.....	.....	.....	1
5.0–5.4	.....	.....	.....	1				
Total	1	9	5	53	21	14	16	2=121
Average Score	1.2	0.72	1.02	1.47	1.79	1.99	2.31	2.35
Standard Deviation	.....	0.61	0.27	1.11	1.06	1.14	1.14	2.15

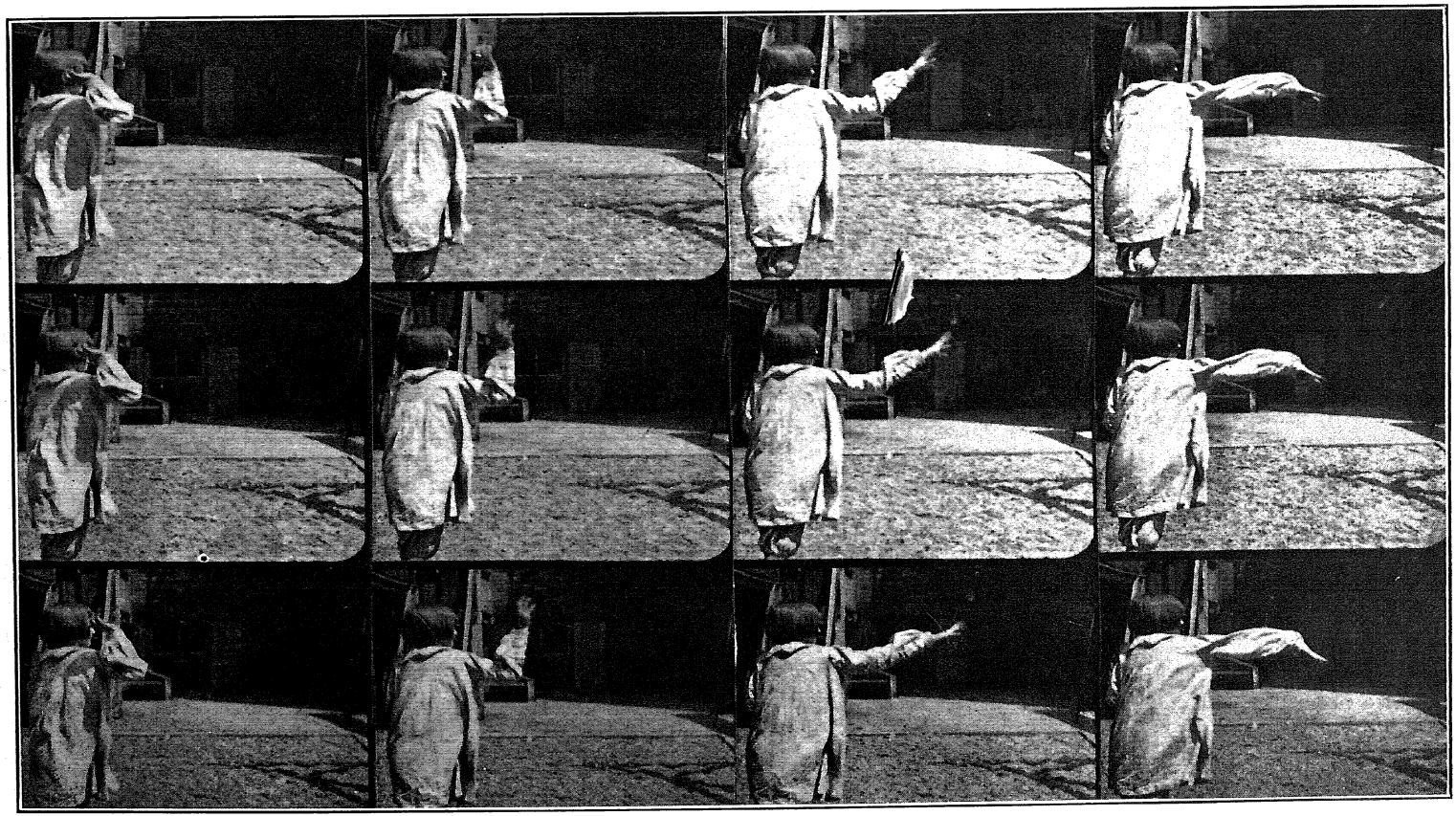

FIG. 14A. FILM STUDY OF A GIRL THROWING AT A TARGET.

made by a child is 0.88 and the child had only one-third the amount of practice of the adult.

The individual can observe his own success or failure in this test. It was thought that the analysis of individual throws with regard to the effect of a zero or of striking the bull's-eye might partially explain the variations in the trend of individual performances. This analysis was not made of the children's scores as the distribution of their score values shows so many more zeros than other values and so few nines. It would be

Table XXV

TARGET TEST SCORE

FREQUENCY OF SCORES AT DIFFERENT POSITIONS

Score.....	0	1	3	5	7	9	Total Value	Average Score	Number of Throws
Adults Age 25–45									
a	11	39	236	1130	1116	93	15,046	5.7	2625
*b**	39	131	579	1889	1720	142	24,631	5.5	4500
c	16	56	237	724	582	35	8,776	5.3	1650
d	9	27	129	333	225	27	3,897	5.2	750
e	76	125	374	640	336	21	6,988	4.4	1575
f	132	286	677	1043	514	36	11,454	4.3	2700
g	72	216	464	658	293	19	7,120	4.1	1725
h	125	254	544	776	373	26	8,611	4.1	2100
i	224	243	409	456	231	11	5,466	3.5	1575
Children Age 8–10									
1	239	51	43	20	5	2	333	0.93	360
2*	97	67	90	85	20	1	911	2.53	360
3*	91	74	93	74	27	1	921	2.56	360
4	226	57	44	28	5	.....	364	1.01	360
5	264	50	25	15	6	.....	242	0.67	360
6*	95	61	99	75	29	1	945	2.62	360
7	231	75	65	33	15	1	549	1.31	420
8*	86	70	89	84	29	2	918	2.55	360
9*	244	38	24	21	3	.....	236	0.71	330
10*	206	52	41	21	9	1	352	1.07	330
11	130	44	68	44	13	1	568	1.89	300
12	221	40	19	15	5	.....	207	0.69	300
13	273	17	21	11	8	.....	191	0.58	330
14*	195	58	40	27	10	.....	383	1.16	330

* The asterisks designate males.

necessary to analyze the succeeding throw for each score value with relation to the total number of such score values. Analysis of the particular throws for the adults shows an average score value of 3.8 for the throws following a zero score and an average score value of 4.6 for the throws following a bull's-eye strike. This relationship holds for six of the eight adults and the others had few nines relative to the number of zeros.

Observation of the posture, facial expression, and tenseness of hand muscles in the children, together with the varied courses of the darts suggested the value of a more analytic study of this activity. The cost of ultra-rapid films is so great only a few cases could be studied by that method. Three children were chosen as representative of the different types determined by practice records. The film for the boy who shows such poor performance in the middle of the series was not a success. Illustrations are shown in Figure 14*a* of the girl whose practice curve shows deterioration rather than improvement and of a boy (Fig. 14*b*) who improves at a more regular rate with little differentiation in the various stages of practice, other than the final negative acceleration. The boy threw with very good form, while the girl showed poor form in all tests of motor control. This difference is made clear in the pictures which show the analysis of one throw for each. Ten throws were photographed and the same type of position of arm and hand movement and of course of dart was shown for each of the ten throws. The girl twists her body and her arm from right to left as she throws and the dart may be seen in a vertical position, pointing upward shortly after leaving her hand. It had been observed in a previous test to turn over in the air and to strike the target with feathered end. The tension in arm and hand muscles remains after letting the dart go.

The measurement of the angular changes in movements by means of these pictures is difficult, but promises valuable results. A projectoscope that permits the holding of the picture on the screen while measurements are made is essential. The primary difficulty lies in obtaining pictures that have clear definitions. We realize, also, that the children should not be clothed in a way that obscures the changes in motion. The scientific and commercial viewpoints are so widely different it seems possible to get the desired pictures only by means of a laboratory camera

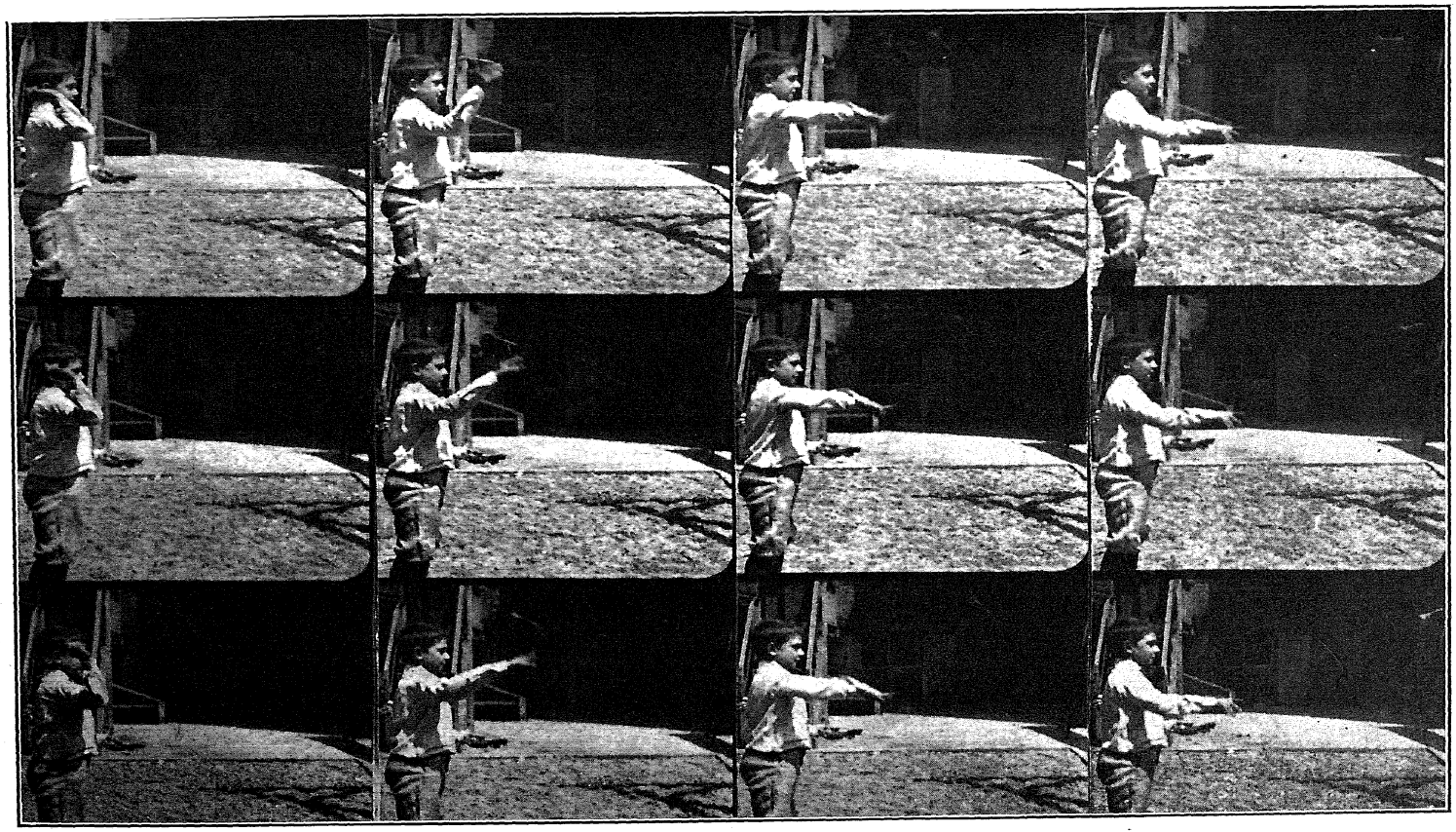

FIG. 14B. FILM STUDY OF A BOY THROWING AT A TARGET.

under control of a laboratory technician. It is also desirable to have children accustomed to such apparatus before pictures are made. The measurements of these two children would not be indicative of expected movements in other children, but we are convinced that such analytical studies of movements would be highly valuable for an understanding of practice effects, of age differences, and of differences in muscular control due to temperament or to specific emotional stimulation.

These are not shown as representative of sex differences but were chosen to illustrate types of performance and for a study of the movements. There were few records of girls for comparison with boys in the target test and no statistical study of sex differences has been made. The scores in the practice series show superiority of the boys.

Motor Co-ordination—

The material used consisted of a metronome, a stop-watch, and blanks of the Hopkins series of co-ordination tests. The two forms used are illlustrated in Figures 15 and 16 showing actual records made. The child was instructed to trace a path with a pencil without touching the sides, but in tracing a given segment to make a stroke of the pencil to the beat of the metronome. This was set at seventy-six beats per minute for both forms. The nine- and ten-year-old children were given the rate of one hundred beats per minute in their last performance. The simple form was devised primarily for the youngest children, and the accessory lines omitted to prevent the distraction of attention from the path. It was difficult in many cases to get compliance with instructions in making the rhythmic form of stroke suggested by the metronome. The measurement of such responses was suggested by the failure of some children to succeed in the rhythmic responses asked for in their activities during a music period when these activities were accompanied by instruments or singing. The number of strokes for a blank should have been the same for all and should have been made at the same rate. The only difference in time should have resulted from the time taken to move the hand from the end of one line to the beginning of the next. Records for adults as well as children show a tendency to hasten or to delay the stroke, requiring either less or more time for a line than the conditions of the

experiment permits. The variation is small for the adults so far studied. With some of our young children it is relatively wide. The time for the tracing of one blank was kept with stop-watch. Qualitative judgment as to rhythm was recorded as

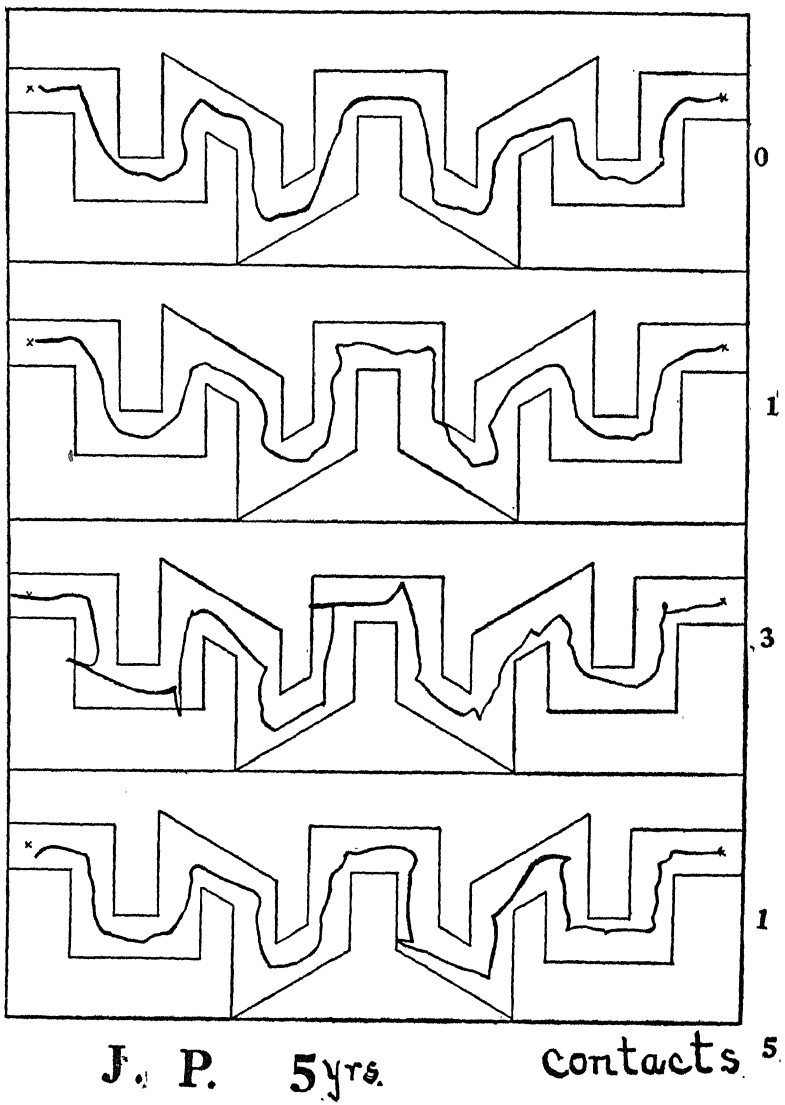

FIG. 15.—Actual record in motor co-ordination test, simple form.

excellent, good, fair, poor, or no rhythm. The score for each blank was the total number of contacts or times the lines were touched.

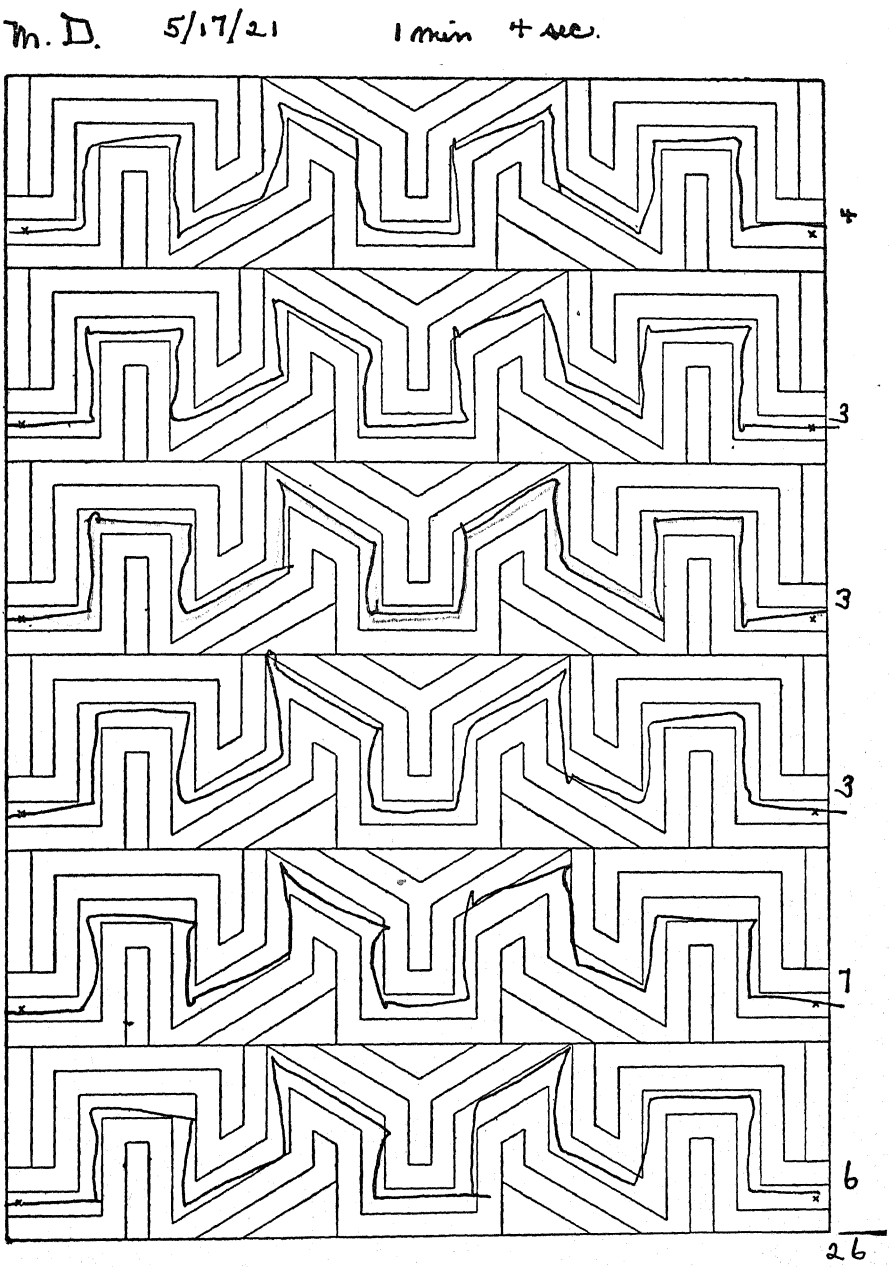

FIG. 16.—Actual record in motor co-ordination test, complicated form.

AGE DIFFERENCES

Results for the simple form given in Table XXVI show a decreasing number of contacts with age. This form is a good measure for ages four, five, and six years, but too easy for

Table XXVI

MOTOR CO-ORDINATION CONTACTS

	Form B. J. 76 Beats per Minute							Form J. D. 76 Beats per Minute					Form J. D. 100 Beats per Minute		
Age.....	3	4	5	6	7	8		7	8	9	10		9	10	
Contacts							Total					Total			Total
0–2	...	8	12	13	10	1	44	1	....	....	....	1			
3–5	...	3	4	10	3	...	20	....	....	....	....	.....	1	1	2
6–8	...	4	5	3	...	...	12	1	1	....	....	2	.....	1	1
9–11	...	1	2	1	...	...	4	....	3	2	....	5	.....	1	1
12–14	...	1	2	...	...	...	3	....	2	1	....	3	.....		
15–17	...	3	...	...	...	...	3	....	3	1	....	4			
18–20	1	1	...	...	...	...	2	3	1	1	1	6	2	2	4
21–23	...	2	...	...	...	...	2	....	1	....	2	3			
24–26	...	...	...	...	...	...	.....	2	1	2	....	5			
27–29	...	...	...	...	...	...	.....	3	1	....	....	4			
30–32	...	...	...	...	...	...	.....	4	....	....	....	4			
33–35	...	...	...	...	...	...	.....	1	3	....	1	5	1	3	4
36–38															
39–41	...	...	...	...	...	...	.....	2	....	....	....	2			
42–44	...	...	...	...	...	...	.....	....	....	1	....	1	.....	1	1
45–47	...	...	...	...	...	...	.....	1	....	....	....	1			
Total....	1	23	25	27	13	1	90	18	16	8	4	46	4	9	13
Arithmetic Mean....	18	7.9	4.0	3.0	1	1	.....	26.5	18.8	19.9	24.3	.....	19.3	22.8	
Median....	...	6.0	3.0	3.0	0	1	.....	27.5	16.5	17.0	21.5	.....	18.5	20.0	

older children. A more rapid rate might be used for ages six and seven. A more difficult form was used in the retest of the children above six. The actual number of contacts is greater than for the simpler form, but the age differentiation is not clear above seven. A faster rate was tried out for the nine- and ten-year-old children, and no more contacts are made at one-hundred beats per minute than at seventy-six.

Summary

The Dynamometer or Strength of Grip Test—

In strength of grip there is an increase in the number of kilograms pulled with increasing chronological age, the absolute increase ranging from 1.2 to 2 kilograms for ages six to ten

years. The variability within an age group is greater than the variation from year to year.

The influence of relative weight for height is significant. The tendency toward an increase in pull with increasing chronological age is only a little greater than the tendency shown toward an increase in pull with increasing weight to height ratio.

There are few young children who show consistent superiority of one hand in consecutive trials and in annual retests in the dynamometer test. There is a marked tendency toward ambidexterity or right-handedness with increasing chronological age.

There is a consistent superiority of the boys at each age.

The dynamometer test proves to be a very stable measure as indicated by the reliability coefficient.

Alternate Tapping, or Rate of Co-ordinated Movements—

There is a definite increase in number of taps with increasing chronological age.

There are also marked practice effects.

There are wide individual variations in relative performance throughout the course of a continued performance, which vitiate direct conclusions as to fatigue effects when the index of fatigue is determined by computations of amount of variation for specified intervals. Such a measure is not reliable in retests at intervals of a year.

The girls are in general superior to the boys in rate of co-ordinated movements, but they are less accurate in actual performance. The boys of this group show a greater variability, but the difference is slight.

There is a slight tendency shown for Weight-Height Index to influence tapping rate but this is not so marked as the influence upon strength.

The test shows a fairly high reliability coefficient.

Steadiness of Hand—

There is evident a slight tendency toward increase in steadiness with increasing chronological age. It is indicated that the testing procedure should be varied for the determination of valid age differences. Practice seems the more significant factor in the determination of efficiency.

Results for these ages do not show consistent sex differences.

Target Test or Precision of Movement—

The actual scores show an increase with increasing chronological age. There is wide variability at each age and a marked contrast between children and adults in accuracy of single throws.

There are marked individual differences in general bodily posture and accessory movements which factors condition the efficiency in performance. These differences can be clearly shown only by photographic reproductions of the rapid movements.

Motor Co-ordination in Rhythmical Tracing—

A simple form shows good age differentiation up to seven years. A graded series would be desirable with a practice series given for each form at a single testing.

Age differences as determined by consecutive measurements of the same children at intervals approximating a year, are greater than those obtained from single measurements of large groups. It is indicated that there are age differences not resulting from practice, but the influence of practice is significant. Tests which show decided practice effects should be administered in such a way that the rate of improvement is markedly retarded and an approximate level of efficiency has been attained before the performance in a given test period is taken as an age score.

CHAPTER IV

MENTAL DEVELOPMENT AS MEASURED BY GRADED SERIES OF TESTS

THE Stanford Revision of the Binet-Simon Scale and the Pintner and Paterson Scale of Performance Tests were given to the children above two years of age. In addition to the children in the City and Country School, these tests were also given to other groups of children under eight years of age to supplement the numbers for these early years for which so few data are available. These groups included eighty-one children in Public School 95 of New York City, which is primarily an Italian group; seventy-two children in the Kindergartens and First grades of the Friend's Seminary, the Ethical Culture School, and the St. Agnes Chapel School. These are private schools in different sections of New York City.

THE STANFORD-REVISION OF THE BINET-SIMON SCALE

The procedure outlined by Terman (24) was followed in the use of the Stanford Revision of the Binet-Simon Scale. The average and standard deviation of the Intelligence Quotients for each age group at half-year intervals are given in Table XXVII. The quotients are not expressed decimally but as percentages, for example, a quotient of 125 means that the mental age is 125 per cent of the chronological age. These averages range from 105.5 to 134.5, placing the groups in the superior class according to Terman's classification. The lowest average shown is for the six-year group which included fifty of the public school children, who made lower scores than did the private school children. Of the ninety-two children in this group, the average Intelligence Quotient for the fifty public-school children was 98.3, while that for the private-school group was 115.2. The Italian children may have been handicapped by lack of facility with English, as Italian is spoken in many of their homes. Certain habits of dress also condition the responses

Table XXVII

INTELLIGENCE QUOTIENTS FOR 616 CHILDREN

Age	Number of Cases	Average Intelligence Quotients	Standard Deviation
2 years — 2 years 5 months.....	2	134.5	3.5
2 years 6 months— 2 years 11 months.....	4	122.3	11.5
3 years — 3 years 5 months.....	19	114.6	18.7
3 years 6 months— 3 years 11 months.....	24	115.9	11.8
4 years — 4 years 5 months.....	46	114.0	17.3
4 years 6 months— 4 years 11 months.....	49	115.9	12.5
5 years — 5 years 5 months.....	49	114.4	11.9
5 years 6 months— 5 years 11 months.....	61	115.8	11.9
6 years — 6 years 5 months.....	45	115.3	11.2
6 years 6 months— 6 years 11 months.....	92	105.5	12.5
7 years — 7 years 5 months.....	47	108.9	11.9
7 years 6 months— 7 years 11 months.....	33	109.7	10.3
8 years — 8 years 5 months.....	33	110.4	11.5
8 years 6 months— 8 years 11 months.....	28	106.3	18.4
9 years — 9 years 5 months.....	24	108.8	9.6
9 years 6 months— 9 years 11 months.....	20	112.1	12.0
10 years —10 years 5 months.....	18	107.5	11.1
10 years 6 months—10 years 11 months.....	10	112.9	12.6
11 years —11 years 5 months.....	7	111.6	10.3
11 years 6 months—11 years 11 months.....	4	110.3	7.4
12 years —12 years 5 months.....	0		
12 years 6 months—12 years 11 months.....	0		
13 years —13 years 5 months.....	1	106.0	
Total.....	616		

for the early years. It was observed that the Italian children who failed almost universally in tying a bow knot, wore button shoes and upon inquiry it was ascertained that these children rarely wore shoes with laces. We also find, however, that the American four-year-old frequently fails to tie a knot or to button his coat when the home environment has provided someone to do these things for him. It is shown by the averages and standard deviations that approximately two-thirds of each age group under seven and one-half of each age group above seven, make Intelligence Quotients that would classify them as superior in mental ability. The averages decrease with age though the variability within the group is relatively constant with a few exceptions, hence the trend is toward a general reduction in Intelligence Quotients with increasing age.

While some of these children are clearly superior in mental ability, we do not believe that they are, as a whole, of the high level which the Intelligence Quotients taken at absolute values indicate. Certain tests in the Three-, Four-, and Five-year groups of the Stanford Revision scale are greatly influenced by environmental conditions. The child who enters a nursery school at two or three years of age is stimulated to participate in activities and to develop motor control which a child rarely gains who remains at home until he is six years old, especially if he is the only child. The home training varies widely with regard to the specific activities of these children and we find great variability in performance at three. For example, some children know money, know Right and Left, can count, and have been taught to read; others have not been stimulated to learn these responses and some have been prevented from so doing by the substitution of other activities. We find some children of high Intelligence Quotients at three showing a decrease with each annual retest, while others show a gain. A girl who was first tested when three years old, had an Intelligence Quotient of 167; a year later, 163; eleven months later, 149; and seven months later, 148. Another girl was first tested when three years, three months old, and had an Intelligence Quotient of 112; one year later, 121; thriteen months later, 130. A girl who maintained a constant quotient was first tested at three, making an Intelligence Quotient of 120, and she varied from this only one point in three tests at intervals of one year. Two boys who were first tested before the age of four showed the following changes in Intelligence Quotients in successive tests: (a) 102; 122 (a year later); 126 (six months later) and (b) 83; 102 (fourteen months later); 121 (thirteen months later).

The tendency toward higher values of the Intelligence Quotient in these early years is more clearly shown in Table XXVIII, and Figure 17 where the quotients from retests of the same children are given. Between ages three and six the mental age increases at a greater rate than chronological age. This again indicates the influence of training upon results of tests for the early years in this scale. After six the change in the Intelligence Quotient seems conditioned more by the absolute value of the quotient than by chronological age. This factor will be considered later. When the same children are retested we find average differences in Intelligence Quotients

Table XXVIII

RESULTS OF RETESTS OF 78 CHILDREN IN STANFORD REVISION OF BINET-SIMON SCALE

	Stanford Revision I. Q.					Interval Between Tests in Fractions of a Year				Differences Between Tests Regardless of Sign			
First test at.....	I. Q. 1	I. Q. 2	I. Q. 3	I. Q. 4	I. Q. 5	Int. 1	Int. 2	Int. 3	Int. 4	Dif. 1	Dif. 2	Dif. 3	Dif. 4
2 Years													
Number of cases.....	1	1	1	.....	.....	1	1	.....	.....	1	1		
Average.....	120.0	119.0	120.0	.....	.....	1.0	1.1	.....	.....	1	1		
3 Years													
Number of cases.....	10	10	10	1	.....	10	10	1	.....	10	10	1	
Average.....	112.0	119.8	122.6	148.0	.....	0.89	1.20	0.6	.....	12.0	7.6	1	
Standard Deviation.....	23.3	17.9	12.0	.....	.....	0.39	0.51	.....	.....	7.3	5.2		
4 Years													
Number of cases.....	28	28	28	10	5	28	28	10	5	28	28	10	5
Average.....	115.4	120.5	119.7	115.8	115.8	1.34	1.02	0.94	0.84	7.9	6.4	5.7	2.0
Standard Deviation.....	12.9	12.8	8.0	5.2	4.9	0.61	0.358	0.10	0.14	7.7	4.3	2.8	2.1
5 Years													
Number of cases.....	15	15	15	6	.....	15	15	6	.....	15	15	6	
Average.....	107.9	112.8	111.9	110.0	.....	1.01	0.93	1.08	.....	5.7	4.7	4.3	
Standard Deviation.....	7.9	6.4	6.1	5.6	.....	0.29	0.05	0.09	.....	3.2	3.0	2.4	
6 Years													
Number of cases.....	11	11	11	2	1	11	11	2	1	11	11	2	1
Average.....	115.9	115.6	115.8	111.5	102	1.4	0.97	0.7	0.8	2.4	4.1	2.5	1
Standard Deviation.....	13.8	12.4	12.2	8.5	.....	0.39	0.15	0.1	.....	2.1	3.9	1.5	
7 Years							0						
Number of cases.....	3	3	3	1	1	3	3.0	1	1	3	3	1	1
Average.....	104.0	106.3	108.7	124	126	1.47	0.9	0.6	1.0	5.0	5.0	5.0	2.0
Standard Deviation.....	3.7	9.4	14.8	.....	.....	0.08	0.08	.....	.....	3.7	4.3		
8 Years													
Number of cases.....	8	8	8	3	.....	8	8	3	.....	8	8	3	
Average.....	107.9	112.5	117.4	124.7	.....	1.04	0.88	0.8	.....	4.6	5.4	3.3	
Standard Deviation.....	7.8	9.2	7.9	1.4	.....	0.26	0.17	0	.....	2.9	5.6	1.7	
9 Years													
Number of cases.....	1	1	1	.....	.....	1	1	.....	.....	1	1		
	106	109	107	.....	.....	0.9	1.0	.....	.....	3	2		
10 Years													
Number of cases.....	1	1	1	.....	.....	1	1	.....	.....	1	1		
	95	98	105	.....	.....	1.0	0.6	.....	.....	3	7		

for the age groups ranging from 2.5 points to 12 points, with a range of 1.5 points to 7.7 points in standard deviations. This shows a decided lack of constancy in the Intelligence Quotients for these young children. The range of actual differences for 125 children who were retested was from 0 to 32 points. Considering the direction of difference the points ranged from —17 to +32. The differences between the first and second tests for the group of 125 children show that there was no change in Intelligence Quotients for nine, or 7 per cent of the cases; a loss for thirty-four, or 27 per cent; a gain for eighty-two, or 66 per cent. Twenty-three cases changed ten or more points, six cases changed twenty or more points. The children who were first tested at three or younger show greater instability

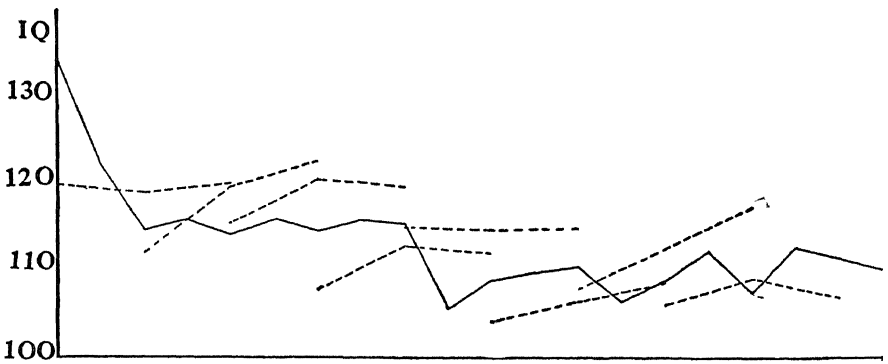

FIG. 17.—Age differences in intelligence quotients. Continuous black line represents large groups of different ages, dotted lines represent successive intelligence quotients attained by the same children grouped according to the age at first testing.

on retests, averaging greater gains and losses than the older children. Those who were first tested at seven or older show the greatest stability in Intelligence Quotient. Of the 331 retests made, 8.43 per cent show a change in Intelligence Quotient greater than 10; 1.5 per cent showed no change; 70.4 per cent made gains; 28.1 per cent showed losses. These figures may be compared with those given by Garrison (6). Of 468 retests, he found that actual differences ranged from —15 to +.15; 8.5 per cent showed differences greater than 10 in I. Q.; 7 per cent showed no change; 55 per cent made gains; 38 per cent showed losses. Stenquist (23) has analyzed data presented by Terman, Garrison, and Rugg, and has shown that an Intelligence Quotient may vary by as much as 20 points in from 2 to 11 per cent of the cases according to the different investigators.

The statement of average change in Intelligence Quotient as given by various investigators ranges from 4.5 to 7 points. The average, however, quite obscures the large individual variations and since this series of tests is used primarily for individual diagnosis, it is essential that further revision or supplementation be made. The coefficients of correlation have shown relatively high predictability as to rating by the Stanford Revision. The coefficients obtained by Garrison were as follows:

298 retests after one year r = 0.88
127 retests after 2 years r = 0.91
43 retests after 4 years r = 0.83

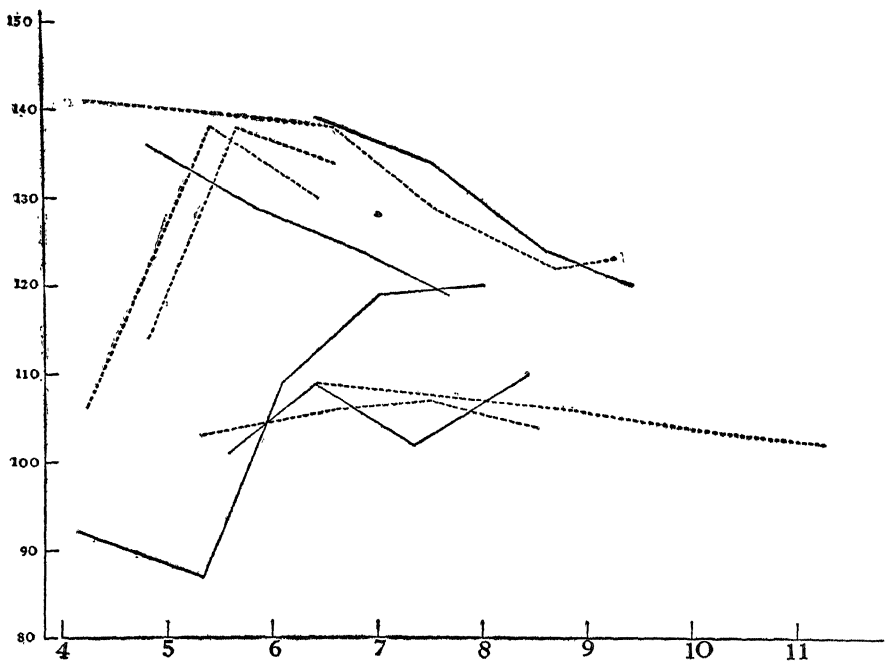

FIG. 18.—Individual growth curves in intelligence as measured by the Stanford Revision Scale. The dotted lines show successive intelligence quotients for girls; continuous lines, for boys.

Baldwin and Stecher give coefficients ranging from 0.75±.049 to 0.94±.012. With the wide range of variations that we have cited we obtained a coefficient of 0.80 for 125 cases that we retested. While a tendency toward constancy in rating is indicated, it is the more important that an analysis be made of the conditions under which inconstancy results. Our finding of such large variations in a group of children under the same

school environment and tested by the same examiners from year to year emphasizes the need of analysis of the responses to the separate items and the supplementation of the scale by the addition of other types of performance, especially for the ages below seven, that may not be so greatly influenced by training.

In Figure 18 the variability in growth as measured by In-

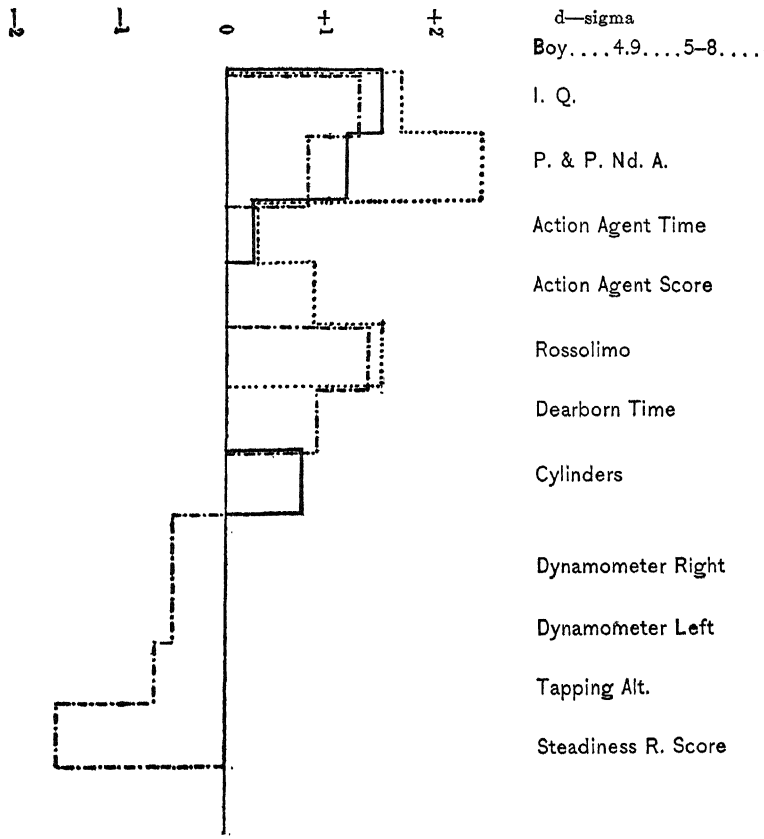

FIG. 19.—Individual profile graph of mental traits.

telligence Quotients is illustrated. These cases were selected to illustrate the three types: first, those who show a decrease in succeeding examinations; second, those who show an increase; third, those who remain fairly constant. In Figures 19 to 22 individual profiles show the growth in various traits including the anatomical, psycho-physical, and graded series of measurements with certain specific test scores. The measures are given in

terms of the deviation from the average of the individual's age group.

The following descriptive accounts of two of the subjects illustrate the wide individual differences found.

Subject 6: Boy. At first testing when three years and five months old, his attention was of short duration as compared

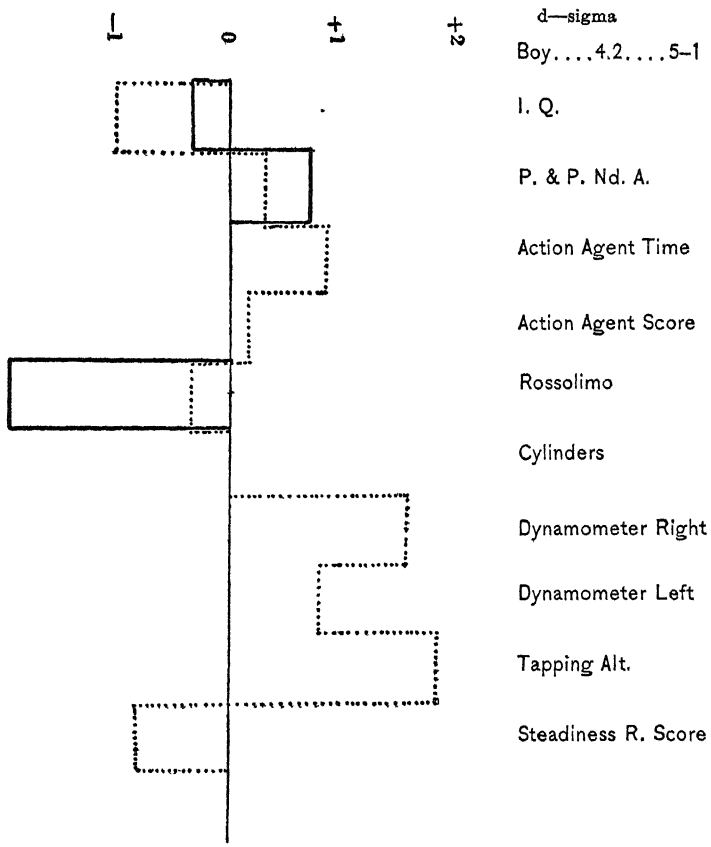

FIG. 20.—Individual profile graph of mental traits.

with the others of the three-year group. It was difficult to secure co-operation and he made low scores in speed and accuracy under controlled conditions even for a brief time. He seemed to have gained little appreciation of form or space. Exaggerated responses to tactual stimulation, which he sought, were observed, and his activities throughout the day were primarily of a routine type such as pushing a block back and forth with one hand and making a choo-choo sound in accompaniment.

Sometimes this was a train, again an animal. Stimuli ordinarily considered unpleasant as frogs or snakes he handled with seeming pleasure. On the linguistic side his responses were usually non-verbal, and whining and screaming were frequent at the slightest interference. He did not adapt to the group, his emotional reactions were poorly balanced and there was marked retardation in the mental development.

It is evident in the profile that a year later he was still below

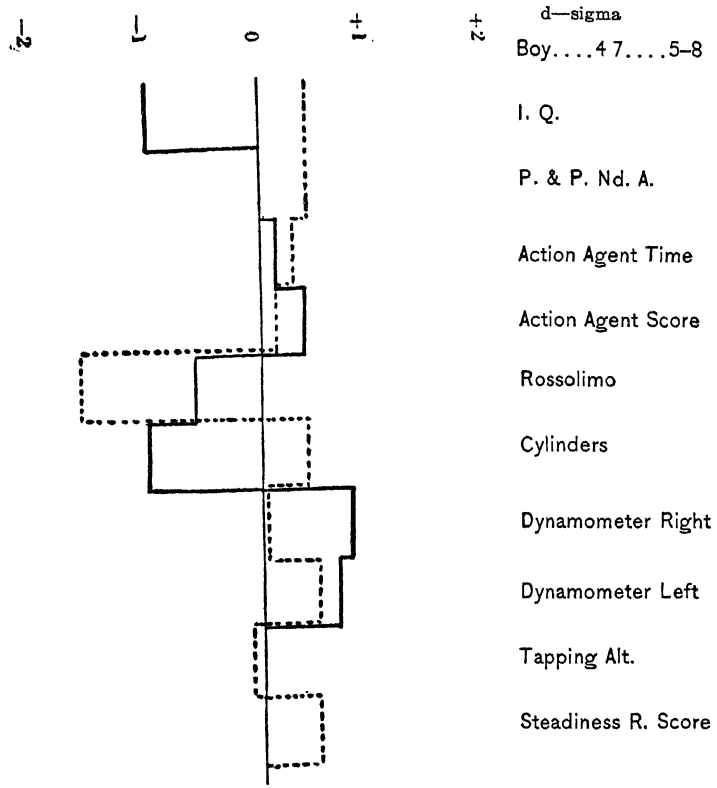

FIG. 21.—Individual profile graph of mental traits.

the average of his age group except for the action-agent associations. The teachers had asked the co-operation of the parents in the arrangement of a daily schedule which would require quick and accurate responses without so much opportunity for dawdling. The measurements made the following year show a great improvement.

Subject 1: Girl. This subject is an only child of parents who were married at a relatively late age. They are artists

and she was in close companionship with them during the first four years of her life. She walked and talked early, saying sentences of six or seven words at two years of age. At four, the teachers reported her as "wonderfully advanced mentally" and there seemed to be unanimity as to her unusual ability and sturdiness. She liked to read and her social contacts with adults doubtless increased her vocabulary. The profile indicates all-round development above the average. Her drawings, paintings, athletic and dramatic performances also show this ability in many types of activities.

The definition of normality as determined by the Intelligence Quotient of 1.00 or 100 assumes the constant increase of a year in mental age with each year of chronological age for children who test exactly normal. This assumption, however, when applied to those who have an Intelligence Quotient above or below 100, implies that the rate of mental growth decreases with advancing age and that the Intelligence Quotients above 100 will decrease with increasing age, while those below 100 will increase. The assumption of constancy of the Intelligence Quotient requires that the rate of mental growth for the child of a high Intelligence Quotient shall exceed that for the child of a lower Intelligence Quotient. Our data have shown that there seems to be a decrease in rate of mental growth after the age of six. Constancy in rate of mental growth for those of varying levels of ability is not shown. In Table XXIX the gains or losses in Intelligence Quotients for successive tests of 125 children are shown. The groupings are made according to the value of the Intelligence Quotient irrespective of chronological age. It is evident that those of high mental ratings show losses rather than gains in Intelligence Quotients obtained at intervals approximating a year for most cases, and that the losses relative to the gains tend to increase in amount with successive tests. Those of lower intelligence ratings more frequently show gains than losses and the relative gain decreases with successive tests. It is recognized that this group includes no children of very low Intelligence Quotients and that with few exceptions the ages at first testing range from two to eight years. Garrison reports a greater gain for those of high Intelligence Quotients, but his subjects ranged from eight to sixteen years and included some of lower ratings than we have considered. We believe that we have a sufficiently large group representative of

Table XXIX

GAINS OR LOSSES IN INTELLIGENCE QUOTIENTS FOR THOSE OF VARYING LEVELS OF MENTAL ABILITY

TIME INTERVAL IN FRACTIONS OF A YEAR

Intelligence Quotients	Number of Cases	Range of Points	Average Interval. I	Total		Number of Cases	Average Interval. II	Total		Number of Cases	Average Interval. III	Total		Number of Cases	Average Interval. IV	Total	
				Gain	Loss			Gain	Loss			Gain	Loss			Gain	Loss
Girls																	
167	1	.....	.....	.....	4	1	0.91	.....	14	1	0.59	.....	1				
141	1	.....	.....	.....	3	1	0.92	.....	9	1	1.08	.....	7	1	0.58	1	
130–139	6	0–17	0.83	.....	23	4	1.25	3	3	1	0.83	.....	6				
120–129	8	0–15	1.33	14	31	2	1.01	1	1								
110–119	21	0–24	1.21	136	18	16	1.24	33	71	4	0.94	4	12				
100–109	21	0–32	1.17	133	15	12	0.92	39	16	3	0.89	.....	8	1	0.84	1	
90– 99	3	2– 7	0.89	9	.....	2	0.83	12									
80– 89	2	4– 9	1.29	13	.....	1	2.25	9									
Boys																	
130–139	4	1–12	1.11	.....	15	4	1.35	3	27	2	0.83	.....	9				
120–129	7	0–11	1.16	21	26	5	0.85	1	23	2	0.92	.....	1	1	0.83	.....	6
110–119	14	0–13	1.58	40	23	8	1.02	26	10	2	1.05	.....	16				
100–109	22	0–20	1.16	126	8	14	0.90	57	16	4	0.85	13	11	2	0.96	2	
90– 99	11	0–25	1.16	89	9	6	0.95	39	6	2	0.96	10	3	2	0.96	3	
80– 89	3	1–19	1.53	37	0	2	0.99	19	1								
70– 79	1	28	1.09	28													

this age to indicate that the high Intelligence Quotient obtained in the early years will not remain constant. The child may retain his relative position in his group, but the classification according to absolute value of the Quotient as very superior or as a genius is not directly applicable as a prognosis of his future rank among his peers.

The frequency of different values of Intelligence Quotients for boys and girls as given in Table XXIX show that the girls are slightly superior to the boys. The average quotient for the girls at the first testing was 113.7; at the second testing, 117.2; for the boys, 108.2 at the first testing, and 112.4 when retested. A range of fifty points, or from 90 to 140, includes all but four of each sex. The extreme cases for the boys, however, are at the lower part of the scale while two girls make high Intelligence Quotients.

Relation of Stanford Revision to Other Measurements

The coefficients of correlation between mental age and measurements of anatomical and physiological characteristics are small if the factor of chronological age is eliminated. These values are given in Table XXX. The coefficients of correlation between mental age and Weight-Height Index, mental age and strength (dynamometer), are fairly high but they become very

Table XXX

COEFFICIENTS OF CORRELATION BETWEEN MENTAL AGE AND OTHER TRAITS

Mental Age With	r	Chronological Age Constant	Wt.-Ht. Constant	Chronological Age and Wt.-Ht. Constant
Chronological age	0.88±.01	.....	0.70±.03	
Blood pressure, systolic	0.42±.04	0.02±.07	0.10±.06	
Pulse rate, increase after-jumping	0.17±.10	0.19±.10		
Weight-height index	0.68±.02	0.04±.05		
Strength	0.71±.03	0.13±.08	0.45±.08	0.03±.07
Performance scale, Median age	0.84±.02			
Rossolimo pictures	0.81±.01	0.31±.01		
Mental age a year later	0.80±.003			

small when the partial correlation method is used and chronological age is held constant. It has been shown in the preceding pages that the Weight-Height Index increases with chronological age and influences to a marked extent the strength score. There is but slight tendency for the mental age to vary directly with these physical traits. It is suggested that further study

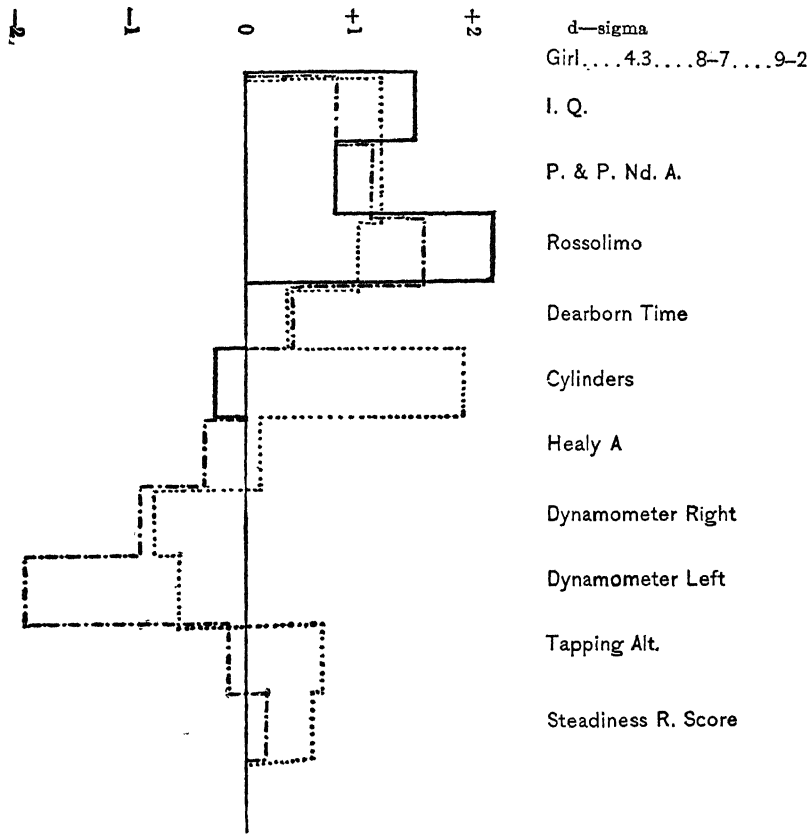

FIG. 22.—Individual profile graph of mental traits.

of variations in pulse rate with control of the other factors known to influence this rate might show a more direct relationship between mental performance and changes in the pulse rate.

There is a definite relationship shown between the Performance Scale and the Stanford Revision, but it is also indicated that some differentiating tests are included. Discussion of the Performance tests will give further indication of the value of these tests in supplementation of the Stanford Revision for the

early years. The Rossolimo graded picture series gives almost as high a coefficient of correlation with mental age as does the longer series of tests in the Performance Scale.

The Pintner-Paterson Scale of Performance Tests

The procedure followed in the administration of the tests in the Performance Scale was that described by Pintner and Paterson (16). The scale permits of varying numbers of tests at different ages, but gives few scores for children below five. In the progress of the experimentation in the particular performance tests, more tests were added to the series for the children under six. Careful study of the data, a report of which has been published (12), indicated a combination of tests that seem most satisfactory for each age group. There are so few data for such performances by the child below the age of five, we are giving the tables for each of the tests in the Performance Scale that was used. The data are then supplementary to that given by Pintner and Paterson. However, we have used half-year intervals and the scores for year groups will have to be computed for direct comparison. It is an advantage, we believe, to group the scores for the young child by half years. The children of our study are as a group rated superior by the Stanford Revision scale, and this adds to the importance of giving the distribution of scores for each age in the particular tests. These are shown in Tables XXXI to XL inclusive.

Consideration of the median age scores, given in Table XLI for each age group at half-year intervals, shows that after the age of four and a half years the children of the present study make scores superior to the norms given by Pintner and Paterson. The amount by which they exceed the norm increases with increasing chronological age, ranging from a half year at five to two years at ten. Study of the individual tests has shown that few offer difficulties for the older children that will differentiate abilities and will permit an increasing score. The time limit method for the young child also fails to differentiate sufficiently his abilities. This is evident from the number at three and four years of age failing to complete many of the tests. The procedure followed with the Seguin Formboard of giving three trials seems a better method for these ages in all the formboard tests and we believe that at least two trials should

Table XXXI

MARE AND FOAL TEST, TIME

Age	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	
Seconds																		
0–19	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	1	2				
20–39	.....	.....	.....	.....	2	4	6	9	22	17	3	.....	.....	7	10	7	2	
40–59	.....	1	3	6	6	17	21	13	28	18	7	2	1	1	.....	2	1	
60–	.....	.....	1	10	8	12	14	6	10	3	2	.....	.....	1				
80–	.....	1	4	10	9	6	4	1	4	2	.....	.....	.....	1				
100–	.....	1	1	3	4	5	3	3	3	1								
120–	.....	2	1	4	2	3	3	1	1									
140–	.....	.....	1	2	1	1												
160–	.....	1	1	.....	1	.....	.....	.....	1									
180–	.....	1	1	.....	2	.....	1	.....	.....	.....	.....	1						
200–	1	2	.....	1	1	1												
220–	.....	1	.....	1	1													
240–	.....	.....	1	1														
260–	.....	.....	.....	1														
280–																		
300–	.....	1	1															
D. N. C.	.....	.....	.....	4	1													
Number Completing Test..	1	11	15	39	37	50	52	33	69	41	12	3	2	12	10	9	3	=399
Average	210	163.4	124.3	102.7	94.1	72.1	66.5	54.4	53.6	47.2	47.9	89.3	36.5	38.4	28.3	29.4	31.7	
Standard Deviation	.....	68.5	73.0	51.5	49.7	35.3	29.8	25.0	30.2	16.9	14.3	65.6	13.5	18.1	3.9	8.1	10.3	
Median	210	180	89	92	89	66	59	52	49	45	56	51	29	34	29	34	34	
P. & P. Median	.....	.....	.....	.....	.....	107	.....	71	.....	62	.....	48	.....	41	.....	36	34	

Table XXXII

MANIKIN TEST SCORE

Age	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	
Score																	
0	3	2	1	3	3	1											
1	.....	2	1	4	1	1	3	.....	.....	.....	1						
2	1	4	6	8	8	7	5	3	6	3							
3	1	1	4	15	15	12	8	4	10	5	1	1	1	1			
4	.....	2	3	10	9	13	13	10	11	6	2	1	.....	1	1	1	
5	.....	.....	2	4	5	12	17	12	18	12	1	.....	.....	7	3		
Total	5	11	17	44	41	46	46	29	45	26	5	2	1	9	4	1	=332
Average Score	1.0	1.9	2.8	2.8	3.0	3.5	3.8	4.1	3.9	4.0	3.4	3.5	3.0	4.7	4.8	4.0	
Standard Deviation	2.6	1.3	1.3	1.3	1.3	1.2	1.2	1.0	1.0	1.1	1.4	0.5	.....	1.2	0.4		
Median	0	2	3	3	3	4	4	4	4	4	4	3.5	3	5	5	4	
P. & P. Median	0	0	.....	1.5	.....	3	.....	4	.....	4	.....	5	.....	5	.....	5	

be given for all ages in these tests. It is somewhat difficult to secure the co-operation of the child under four in repeated trials, especially if they follow each other without intervening activities. The child will attempt other manipulations of the blocks than the conditions of the test require. For this age group it is suggested that a scheme of testing be devised which introduces the same tests at intervals throughout the period of testing until three performances of each test have been secured, but not requiring the repetition of any test in immediate succession. The desirability of repeated tests is also indicated by the scores for successive years, as given for Rossolimo Dissected Picture Series in the following chapter. The child who was first tested at three makes approximately the same score

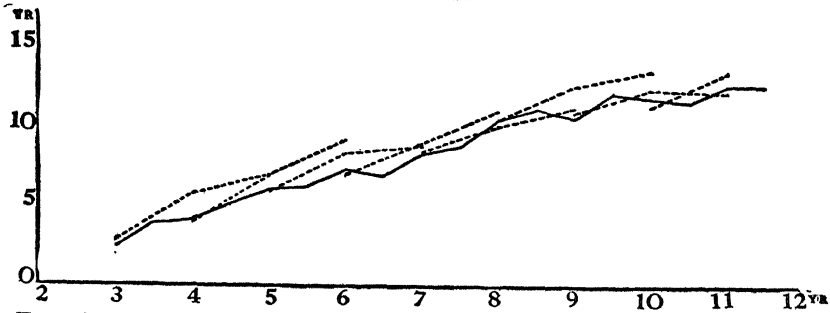

FIG. 23.—Age differences in median age scores for Performance Scale. Continuous black line represents large groups of different ages; dotted lines represent three successive scores made by groups of children who were first tested at the same chronological age.

four years later as the one who was first tested at seven makes four years later.

The median age scores made in successive tests, given in Table XLII show an increase in the initial scores with increasing chronological age and in retests of children of the same chronological age there is a marked increase in score in succeeding years. The increase is slightly irregular, the differences between the first and second tests ranging from one year for the child eleven years old to 3.08 years for the four-year group. The greatest difference between scores made at second and at third tests was 2.26 years, for the four-year group.

Since the increase in median age score for the groups taken according to the age at which they were first tested greatly exceeds the increase with chronological age for the larger general group practice effects are significant. This divergence is shown in Figure 23. This again indicates the importance of more than

Table XXXIII]

SEGUIN FORMBOARD, TIME, FIRST TRIAL

Age	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	
Seconds																			
0–9																			
10–19	.....	.....	.....	.....	.....	1	.....	.....	.....	1	.....	1	.....	1	1	2	3	2	
20–29	.....	.....	.....	.....	1	.....	5	2	3	8	8	8	15	9	13	6	5	1	
30–39	.....	1	.....	.....	2	4	5	13	12	20	18	9	7	3	1	1	1		
40–	.....	.....	.....	.....	1	6	13	16	12	8	5	1	1	1					
50–	.....	.....	.....	1	9	9	6	10	7	9	2								
60–	.....	.....	1	1	6	2	8	8	1	4									
70–	.....	.....	.....	3	2	5	2	2	1	3	1								
80–	.....	1	1	3	6	3	3	1	1	.....	.....	1							
90–	.....	1	2	3	.....	3	2	1											
100–	.....	.....	1	2	4	1	.....	1	.....	1									
110–	.....	1	1	1	5	1	1	1											
120–	.....	.....	.....	1	1	.....	1	.....	.....	.....	.....	1							
130–	.....	.....	.....	.....	1														
140–	.....	.....	2	.....	1														
150–	.....	1	1	1	1		1												
160–	.....	.....	.....	1	1														
170–	.....	.....	.....	1															
180–	.....	.....	.....	.....	.....	2													
190–	1	.....	2																
200–																			
210–																			
220–	.....	.....	.....	1	1														
280–289	1																		
300–309	1																		
360–369	.....	1																	
D. N. C.	3	2	1	.....	1														
Number completing test	3	6	11	19	42	37	47	55	37	54	34	21	23	14	15	9	9	3	=439
Average time	259.7	140.5	126.5	107.4	85.6	67.5	57.5	50.3	44.1	45.2	35.0	36.5	27.4	26.6	23.7	22.3	21.2	20.3	
	49.1	105.7	42.9	43.8	38.8	34.7	26.0	17.3	12.2	10.9	9.8	22.9	4.5	6.6	4.0	4.7	4.2	5·8	

Table XXXIV

SEGUIN FORMBOARD, TIME, SECOND TRIAL

Age	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	
Seconds																			
0–9																			
10–19	.....	.....	.....	.....	.....	1	.....	.....	.....	4	5	4	8	6	11	8	6	2	
20–29	.....	.....	.....	.....	.....	4	10	16	18	19	21	14	14	8	4	2	3	1	
30–	.....	.....	.....	.....	3	9	18	21	16	21	7	2	1						
40–	.....	.....	.....	1	10	5	10	11	1	7	.....	1							
50–	.....	.....	1	3	11	7	7	4	1	2	1								
60–	.....	.....	3	2	5	2	1	.....	.....	1									
70–	.....	.....	.....	4	1	1	1	2											
80–	.....	1	.....	1	.....	.....	.....	1											
90–	.....	.....	.....	2	1	2													
100–	.....	.....	.....	1	2														
110–	.....	.....	.....	.....	1	1													
120–	.....	.....	1	.....	.....	1													
130–	.....	.....	1	1	.....	1													
140–																			
150–	1	.....	.....	.....	3	1													
160–																			
170–																			
180–	.....	.....	.....	.....	.....	1													
190–	.....	.....	1	.....	1														
200–	.....	1																	
210–																			
220–																			
230–																			
240–	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	
D. N. C.	.....	.....	.....	.....	1														
Number completing test	1	2	8	15	38	36	47	55	36	54	34	21	23	14	15	10	9	3	=421
Average time	158.0	142.0	116.5	76.1	68.4	58.9	38.2	37.7	30.4	31.8	25.6	24.3	22.1	21.3	19.1	16.2	19.0	17.3	
		58.0	65.4	23.2	38.1	38.3	11.5	12.6	6.2	9.3	8.4	6.6	3.7	3.8	2.9	2.4	4.9	2.5	

Table XXXV

SEGUIN FORMBOARD, TIME, THIRD TRIAL

Age	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5
Seconds																	
0–9																	
10–19	.....	.....	.....	.....	.....	.....	3	3	.....	4	6	12	9	3	3		
20–29	.....	.....	3	6	8	12	29	18	11	5	3	1	1	5			
30–	.....	2	8	11	19	9	14	5									
40–	.....	4	8	5	2	1	1										
50–	.....	6	1	3	2												
60–	.....	2	2	.....	1												
70–	1																
80–	1	1	1	.....	2												
90–	.....	1															
100–	2																
110–																	
120–																	
130–	.....	1															
140–																	
150–																	
160–																	
170–	.....	.....	1														
180–																	
190–																	
200–																	
210–																	
220–																	
230–	.....	.....	1														
Total	4	17	25	25	34	22	47	26	11	9	9	13	10	8	3	.....	263
Average time	92.8	58.9	54.6	36.2	36.9	28.9	26.9	24.6	24.7	20.7	18.6	17.3	15.8	18.4	16.0		
	14.6	24.5	46.4	8.0	14.5	6.0	5.6	4.7	2.7	3.3	2.0	2.3	3.2	4.3	2.2		
Median	95	55	42	36	35	29	26	25	25	21	18	16	16	23	16		
Sylvester-Median	.....	.....	.....	37	.....	26	.....	23	.....	20	.....	18	.....	16			

Table XXXVI

KNOX CUBE TEST, SCORE

Age	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	
Score																						
0	.....	.....	5	2	2	1	2															
1	3	3	12	5	2	4	.....	5														
2	2	3	4	6	8	7	5	6	3	4												
3	.....	.....	3	2	8	3	6	13	3	4	.....	.....	.....	.....	2							
4	.....	.....	1	2	7	13	5	11	3	2	1	2	1	4								
5	.....	.....	1	4	6	8	12	10	11	3	6	.....	4	3	4	4	1					
6	.....	.....	.....	3	2	8	8	10	9	8	6	3	4	4	11	2	3	1				
7	.....	.....	.....	.....	1	2	6	3	5	3	4	5	4	4	6	13	1					
8	.....	.....	.....	.....	1	.....	1	2	2	5	2	3	5	1	5	6	1	.....	.....	1	1	
9	.....	.....	.....	.....	.....	.....	2	1	2	.....	2	3	.....	4	9	5	1	2				
10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	1	5	.....	1				
11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1	.....	.....	1					
12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1								
Total	5	6	26	24	37	46	47	61	38	29	22	16	19	23	38	35	8	4	.....	1	1	=486
Average score	1.4	1.5	1.5	2.9	3.4	3.9	4.8	4.2	5.4	5.2	6.5	7	6.6	6.9	6.9	7.6	7.3	8.5	.....	8	8	
Standard Deviation	0.5	0.5	1.3	1.7	1.8	1.7	2.0	2.6	1.8	2.0	1.4	1.5	1.5	2.3	1.7	1.5	1.9	1.5				
Median	1	2	1	2	3	4	5	4	5	6	6	7	6	7	7	7	7	9				
P. & P. Median	1	.....	1	.....	2	.....	4	.....	5	.....	6	.....	6	.....	6	.....	7	.....	7	.....	7	

Table XXXVII

SHIP TEST, SCORE

Age	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13
Score																				
0	1	1	1	4	1	5	3	1	1											
1																				
2				1	1		1													
3																				
4			1		5	3	2													
5			1			2						1								
6				5	7	2	6	1	1											
7			1	1	1	1	2	1												
8					3	3	7	1												
9					1															
10				2		2	5		1											
11					2		3	1	1		1									
12			1	1	2	4	4	1		1										
13			1	1	3	4	2		1											
14			2		2	1	4	3	1		1	1								
15				1	2	4	6	1	1	1										
16			1	1	2	5	9	4	1	3	1									
17				1		4	3		3		1	1								
18				3	2	4	2	6	2	2	1	3	4	1						
19				1	1		3	8	2	2	6	6	1	5	1	2	1		1	
20				2	1	7	6	10	8	15	9	14	13	10	8	5	3			1
Total	1	1	9	24	36	51	68	38	23	24	20	26	18	16	9	7	4	0	1	1=377
Average Score	0	0	9.4	10.2	9.8	12.1	12.2	16.5	16.1	18.7	18.5	18.6	19.5	19.6	19.9	19.7	19.8		19	20
Standard Deviation			5.3	6.9	5.2	6.2	5.4	4.6	5.1	2.1	2.3	2.9	0.8	0.7	0.3	0.6	0.4			
Median	0	0	12	12	9	14	13	18	18	20	19	20	20	20	20	20	20		19	
P. & P. Median				0		15		15		17		18		18		19		20		20

Table XXXVIII

TWO FIGURE FORMBOARD, TIME

Age	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	
Seconds																				
11–20					2	1	1	2	4	1	4	5	2		2	1				
21–30			2	3	2	3	10	5	7	6	8	4	6	3	2	1			1	
31–40	1			2	5	3	5	4	4	6	1	4	4	1	2	1		1		
41–		1		1	5	8	2	1	2	2	3	2	3	1	1	1				
51–		1	2	2	1		1		1		1	1	1	1						
61–			1	3		2	1	3	1		1									
71–		1	1	2	3	3														
81–		1	1		3		1	1	2											
91–		1	2			1	1	1												
101–	1						1	1		1	1									
111–			1						1											
121–			1	2	1		1													
131–		1				1														
141–					2						1									
151–			2			1									1					
161–			1			2														
171–	1																			
181–		1	1		1			1		1				1						
191–				1			1													
201–	1					1														
211–			1			1			1											
221–		1																		
231–			1																	
241–																				
251–	1					1														
261–																				
271–					1	1														
281–					1															
291–																				
D. N. C.	7	4	5	8	2	4	4	1												= 35
Number Completing Test..	5	8	17	16	27	29	25	19	23	17	20	16	16	7	8	4	....	1	1	=259
Average Time	155.8	114.5	113.5	68.6	82.3	89.1	51.4	52.9	48.3	45.6	41.6	29.4	32.6	56.7	44.3	32.8	....	35.0	24.0	
Standard Deviation	77.0	61.0	60.4	42.9	69.9	72.3	40.9	40.0	43.8	40.5	31.9	11.8	10.1	54.3	44.7	12.6				
Median	D. N. C.	160	130	75	56	66	35	40	33	34	29	26	31	36	31	30				
P. & P. Median	D. N. C.	.....	200	.....	175	.....	116	.....	62	.....	47	.....	47	.....	47	.....	39	....	29	

Table XXXIX

FIVE FIGURE FORMBOARD, TIME

Age	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	
Seconds																						
11–20								1							1							
21–30							1	1		2		2	3	2	1	2	2	1				
31–40								1	1	1	5	1	4	4	4	1	3	1			1	
41–				1	1	1	2	1	5	7	4	5	6	4	3	2	1	2				
51–				1		2	5	5	6	4	5	2	3	3	2		1					
61–					3		3	3	5		4	3	2		3	1	1					
71–			1	1		3	4	4	1	2	3		2	2								
81–		1		1	1	1	2	2	2		2	1				1				1		
91–		1		1	2	3		3	2	1				1	1							
101–		1		1	2	3	3	1														
111–			2		1	3		1	2	1		1										
121–				1	1	3	1	1	1	1			1									
131–				2	3	2	1															
141–				1		1	2	3	1			1				1						
151–			3				2			1												
161–			1		1	2	1	1														
171–					1	2	1	1														
181–					1				2						1							
191–				1																		
201–			1			1		1	1													
211–			1	1			1	1														
221–								1	1													
231–			2		1																	
241–			1		1			1														
251–		1	1		1																	
261–		1																				
271–					1																	
281–																						
291–			1				1															
D. N. C.	4	1	13	4	7	2	1	3														= 35
Number Completing Test		5	14	12	21	27	30	33	30	20	23	17	21	16	16	8	8	4	0	1	1	= 307
Average Time		161.6	139.1	119.1	139.1	115.0	103.9	103.3	88.3	63.5	56.6	64.8	50.5	49.6	56.8	58.6	38.6	39.5		90.0	34.0	
Standard Deviation		81.9	62.0	50.4	65.8	38.9	58.9	59.7	51.1	33.5	16.3	34.2	22.6	18.1	39.2	36.6	11.9	5.9				
Median	D. N. C.	130	256	137	150	105	86	86	68	55	57	56	47	47	48	46	38	41				
P. & P. Median			D. N. C.		D. N. C.		200		117		97		79		69		64		58		47	

Table XL

THE CASUIST FORMBOARD, TIME

Age	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	
Seconds																						
21–30	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	.....	.....	3	1						
31–40	....	.....	.....	.....	.....	.....	3	.....	1	.....	4	2	6	4	3	3	3	1				
41–50	....	.....	.....	.....	1	1	.....	2	4	6	2	1	2	2	4	1	2	1	....	....	1	
51–	....	.....	.....	.....	1	1	3	2	3	3	3	2	2	4	1	1	2	1	....	1		
61–	....	.....	.....	.....	1	7	3	3	4	1	4	4	2	2	....	1	1					
71–	....	.....	.....	.....	1	.....	2	4	1	1	1	....	1	....	3	1	....	1				
81–	....	.....	.....	1	.....	1	3	1	5	.....	3	1	2	2	1							
91–	....	.....	.....	1	1	1	1	1	4	2	1	....	1	1								
101–	....	.....	.....	.....	.....	1	2	2	.....	.....	1	1	1									
111–	....	.....	.....	1	1	1	1	2	3	2												
121–	....	.....	1	1	.....	3	3	2	2	1	.....	2	....	1								
131–	....	.....	.....	1	.....	.....	2	1	1	.....	.....	1										
141–	....	.....	.....	.....	2	.....	.....	2	.....	.....	.....	1	1	1								
151–	....	.....	.....	.....	1	1	1	2	1	3	1	....	1									
161–	....	.....	1	.....	1	.....	.....	.....	1													
171–	....	.....	1	.....	1	1	1	1														
181–	....	.....	.....	.....	.....	1	.....	2	1													
191–	....	.....	.....	.....	1	1	2	1	.....	1	1	....	2									
201–	....	.....	.....	.....	1	1	1	.....	.....	1												
211–	....	.....	.....	.....	1																	
221–	....	.....	.....	.....	2	1	1	.....	.....	1												
231–	....	.....	.....	1	.....	2	.....	.....	.....	.....	.....	1										
241–	....	.....	.....	.....	3	1	.....	1	1													
251–	....	.....	.....	.....	.....	.....	1	.....	1													
261–	....	.....	.....	.....	.....	.....	.....	1	1													
271–	....	.....	.....	.....	.....	1	1	1														
281–	....	.....	1	.....	.....	.....	.....	1														
291–	....	.....	.....	.....	.....	2	.....	1														
D. N. C.	1	4	5	11	11	16	11	4	2	4	1	....	....	....	....	....	....	....	....	....		= 70
Number Completing Test	....	.....	4	6	19	28	31	33	34	22	22	17	21	17	15	8	8	4	0	1	1	= 291
Average Time	....	.....	190.5	131.8	162.4	145.9	117.5	134.2	104.5	101.8	71.8	87.1	79.2	66.9	49.8	47.9	46.8	57.5	....	54	47	
Standard Deviation	....	.....	59.5	47.4	66.3	79.2	64.3	72.1	59.3	56.2	39.5	52.7	50.2	31.4	19.1	14.7	10.3	14.8				
Median	....	D. N. C.	D. N. C.	D. N. C.	225	225	130	126	92	106	66	67	66	58	46	46	46	50				
P. & P. Median	....	.....	.....	.....	D. N. C.	.....	300	.....	154	.....	106	....	93	.....	78	....	68	.....	66	.....	75	

one trial at a given age. A comparison of the median age scores with those obtained by Pintner and Paterson shows that for the specific tests our group are superior with few exceptions up to the age of six and for certain tests as the Ship Test, Casuist, and Two-Figure Formboard even up to eleven. In our group there are included those who had been tested one, two, three, or four successive years. From twenty to sixty per cent of the cases for the separate year groups have been previously tested. The influence of practice would partially explain the superiority in their scores. It is clear, however, that when only those who have had the same amount of practice and who were first tested at a given chronological age are grouped, the increase in score on successive tests exceeds the difference in initial scores made by corresponding age groups. If we consider ages four, five, and six in Table XLII we find the four-year group increase from a median age score of 4.2 years at first testing, to 7.2 years at the second testing 1.3 years later, and 9.4 years at the third testing a year later. The few cases with later tests reach 11.7 and 11.5 years as median age scores. The initial scores made by the four-, five-, and six-year groups are 4.2, 6.2, and 7.2 years. The groups may not be equivalent in capacity as measured by the Stanford Revision, but since they are all classified as above average such a difference could scarcely account for the contrasting age differences.

Some of the specific tests in the scale show good age progression for all ages we have studied, with decreasing rate of improvement as chronological age and practice increase. Others fail to differentiate after certain ages as indicated by the average scores and standard deviations. The Casuist, Two-Figure, and Five-Figure Formboards, and the Cube test are of value up to the age of ten or eleven. The Manikin test is too easy after the age of six except for the special cases and the other tests fail to differentiate clearly the age groups after nine.

The median age scores as determined by varying combinations of tests does not give as regular progression as the specific tests. It is indicated that more definite standards for the ages below three are needed and that tests more difficult for the ages above nine should be added. The larger numbers for ages four and five that we have studied show that the ability of the young child in such tests is much greater than has been indicated by the scores obtained for small groups.

A combination of tests suitable for the different age levels is suggested, with the addition of certain specific tests for which data are reported in the next chapter. The order of presentation should be that listed, and one trial of each test in the series should be given, and then the repetition of the series should be made in same order of presentation. If a child falls below the median score for his age group in any test, he should be given the series for the next lower age group; if he surpasses the median score for his age group in any test, he should be given the tests in the series for the next higher age group.

Ages Three and Four: Three trials of each of the following tests: Seguin Formboard, Manikin, Two-Figure Formboard, Mare and Foal, Five-Figure Formboard, Cube, *Witmer Cylinders, Rossolimo Pictures* (numbers one to six).

Table XLI

PINTNER-PATERSON MEDIAN AGE, SCORE

Age	Number of Cases	Average	Standard Deviation
3 years — 3 years 5 months.....	10	2.4	2.4
3 years 6 months— 3 years 11 months.....	11	3.9	2.5
4 years — 4 years 5 months.....	34	4.1	2.4
4 years 6 months— 4 years 11 months.....	32	5.2	2.2
5 years — 5 years 5 months.....	46	6.2	0.9
5 years 6 months— 5 years 11 months.....	56	6.4	1.4
6 years — 6 years 5 months.....	48	7.5	2.0
6 years 6 months— 6 years 11 months.....	62	7.2	1.7
7 years — 7 years 5 months.....	42	8.6	2.1
7 years 6 months— 7 years 11 months.....	26	9.1	2.4
8 years — 8 years 5 months.....	24	10.8	1.4
8 years 6 months— 8 years 11 months.....	21	11.6	1.8
9 years — 9 years 5 months.....	21	11.0	2.1
9 years 6 months— 9 years 11 months.....	17	12.6	1.2
10 years —10 years 5 months.....	16	12.3	1.7
10 years 6 months—10 years 11 months.....	8	12.1	1.9
11 years —11 years 5 months.....	7	13.2	1.2
11 years 6 months—11 years 11 months.....	5	13.2	1.0
12 years —12 years 5 months.....	0		
12 years 6 months—12 years 11 months.....	1	14.0	
13 years —13 years 5 months.....	1	14.0	
Total.....	488		

Table XLII

RESULTS OF TESTS ON 107 CHILDREN—PINTNER-PATERSON PERFORMANCE SCALE

INTERVAL BETWEEN TESTS IN FRACTIONS OF A YEAR. DIFFERENCES BETWEEN TESTS REGARDLESS OF SIGN

First test at	P. P. 1	P. P. 2	P. P. 3	P. P. 4	P. P. 5	Int. 1	Int. 2	Int. 3	Int. 4	Dif. 1	Dif. 2	Dif. 3	Dif. 4
3 Years													
Number of cases	10	10	7	1	.....	10	7	1	.....	10	7	1	
Average	2.75	5.8	7.17	12	.....	0.99	1.04	2.3	.....	3.05	1.46	1.0	
Standard Deviation	2.8	0.93	1.59	.....	.....	0.48	0.12	.....	.....	2.70	1.08		
4 Years													
Number of cases	24*	28	17	5	2	28	17	5	2	24	17	5	2
Average	4.15	7.23	9.44	11.7	11.5	1.31	1.01	1.0	0.85	3.08	2.26	1.6	1.0
Standard Deviation	2.75	2.27	2.38	2.44	2.5	0.60	0.37	0.06	0.25	2.60	1.66	1.59	1.0
5 Years													
Number of cases	21	21	12	2	.....	21	12	2	.....	21	12	2	
Average	6.24	8.5	9.15	13.0	.....	1.29	0.90	0.95	.....	2.31	1.17	2.75	
Standard Deviation	0.97	2.15	2.60	1.0	.....	0.74	0.15	0.05	.....	1.85	1.31	2.25	
6 Years													
Number of cases	23	23	17	3	.....	23	17	3	.....	23	17	3	
Average	7.19	9.22	11.49	13.33	.....	1.27	0.96	0.97	.....	2.20	2.19	1.67	
Standard Deviation	1.90	1.54	1.37	0.99	.....	0.61	0.19	0.1	.....	1.98	1.51	0.94	
7 Years													
Number of cases	7	7	5	2	2	7	5	2	2	7	5	2	2
Average	8.71	10.43	11.6	14.0	14.0	1.04	0.94	0.6	0.9	2.29	1.40	1.75	
Standard Deviation	2.0	1.44	0.74	0	0	0.14	0.10	0	0.1	1.02	0.92	0.25	
8 Years													
Number of cases	5	5	1	1	.....	5	1	1	.....	5	1	1	
Average	10.8	13.0	14.0	14.0	.....	1.12	0.9	0.8	.....	2.2			
Standard Deviation	1.63	0.63	.....	.....	.....	0.26	.....	.....	.....	1.12			
9 Years													
Number of cases	10	10	3	.....	.....	10	3	.....	.....	10	3		
Average	11.3	12.8	12.67	.....	.....	0.86	0.97	.....	.....	1.5	1.0		
Standard Deviation	1.62	1.08	0.9	.....	.....	0.26	0.1	.....	.....	0.92	0.82		
10 Years													
Number of cases	2	2	.....	.....	.....	2	.....	.....	.....	2			
Average	11.75	14.0	.....	.....	.....	1.15	.....	.....	.....	2.25			
Standard Deviation	0.25	0	.....	.....	.....	0.05	.....	.....	.....	0.25			
11 Years													
Number of cases	1	1	.....	.....	.....	1.0	.....	.....	.....	1			
Score	11.0	12.0	.....	.....	.....	0.6				1.0			

*Four cases with median age D. N. C.

Ages Five and Six: Two trials of each of the following tests: Seguin Formboard, Manikin, Two-Figure Formboard, Mare and Foal, Five-Figure Formboard, Cube, Ship, Casuist Formboard, *Witmer Cylinders, Rossolimo Pictures* (numbers one to eight), *Dearborn Reconstruction Formboard No. 1 C.*

Ages Seven and Eight: Two trials of each of the following tests: Seguin Formboard, Two-Figure Formboard, Mare and Foal, Five-Figure Formboard, Cube, Ship, Casuist Formboard, *Witmer Cylinders, Rossolimo Pictures* (complete series), *Dearborn Reconstruction Formboard No. 1 C, Healy Picture Completion II.*

Ages Nine to Twelve: Two-Figure Formboard, Cube, Five-Figure Formboard, Substitution, Casuist, *Rossolimo Pictures, Dearborn Reconstruction Formboard, Healy Picture Completion II.*

The coefficient of reliability obtained from correlating the scores made at the first testing with those made at the second testing is 0.97, which is the highest reliability coefficient we have obtained for any test. Since the median age score for the scale, which consists of a series of specific tests, was used in the determination of this coefficient, the reliability coefficient is comparable with that obtained for the mental age score of the Stanford Revision Scale which was 0.80. The two scales give a coefficient of correlation of 0.83. The regressions in the three distributions are practically linear.

Summary

The Intelligence Quotients determined by the Stanford Revision of the Binet-Simon Scale tend to increase with increasing chronological age for ages three to six. From the age of seven upward there is a tendency toward a decrease in Intelligence Quotient when the tests are made at intervals approximating a year.

There is a greater inconstancy of Intelligence Quotients in the early years. This relative instability indicates a marked influence of training upon the ability to perform the tests given for the ages three to six.

The influence of training is also evident from the wide variations found for the same individuals. These variations range from a loss of 17 points to a gain of 32 points. Six cases out

of 125 children changed 20 or more points; 23 cases changed 10 or more points.

In this group, which includes no children of low Intelligence Quotients, in re-examinations, those of highest Intelligence Quotients show losses rather than gains; those of the lowest grouping more frequently gain than lose.

It is not probable that a high Intelligence Quotient obtained at an early age will remain constant.

From the age of seven to eleven a child is likely to retain his relative position in a group as determined by the Intelligence Quotient, but the classification according to absolute value of the quotient is not likely to remain constant.

The norms for the Pintner and Paterson Scale of Performance Tests do not seem valid for the extremes of the scale. The median age scores of the children of this study are superior to the norms given for their ages. The amount by which they exceed the norms ranges from a half year at five to two years at ten.

The practice effects for the tests of this scale are significant. In retests of the same children who were first tested at the same chronological age, there is a greater increase in score from one test to another than the increase that was shown for the larger group for the same age interval.

There is wide variation in the age progression shown by the specific tests in the scale. Some tests fail to differentiate the abilities for the age groups after nine.

The median age scores determined by varying combinations of these specific tests do not give as regular age progression as the specific tests give.

It is indicated that tests of greater complexity should be added to the scale, and that some measurement of practice effects should be made.

This scale gives a high reliability coefficient (.97) and also shows a close correlation with the Stanford Revision Scale (.83).

CHAPTER V

THE ROSSOLIMO SERIES OF DISSECTED PICTURES

THIS test is one included in Rossolimo's profile method and is designated by him as the "capacity to combine." Rossolimo (19) gives illustrations of two series of graded tests each involving the building up of a square from the parts into which it has been dissected. One set shows designs which should be formed when the square is correctly built up. Neither of these series is the exact reproduction of the one we have used though the types of dissections are illustrated and some of the designs are given. The series for which we are reporting data, consists of ten pictures done in water colors on six inch squares of white cardboard. Five pictures are in colors of familiar objects, and five are conventional designs done in black on a white background. These are illustrated in Figures 24 to 26 together with the forms into which they are dissected. Our set of pictures was copied from a set loaned to us by Dr. Mabel Fernald. The difficulty in making the thin cardboard lie flat upon the table led us to make up our set by pasting the cardboard upon thin wood before dissecting the squares. This has made it a more satisfactory test. The pictures were presented in the order given in the illustration. This order is supposed to offer increasing difficulty both as to number and form of pieces into which the square is dissected and as to complexity of design.

The pieces of each picture were lettered on the back A, B, C, etc., to designate their order of arrangement for presentation. This order was an arbitrary one given by Dr. Fernald as presenting the same situation to each subject. It can easily be seen that chance arrangement would offer many opportunities for suggestions and for a much quicker performance. The pieces, taken in this arbitrary order were placed one upon another and laid upon the table in front of the child. The instructions were: "See if you can put these pieces together so that they will make

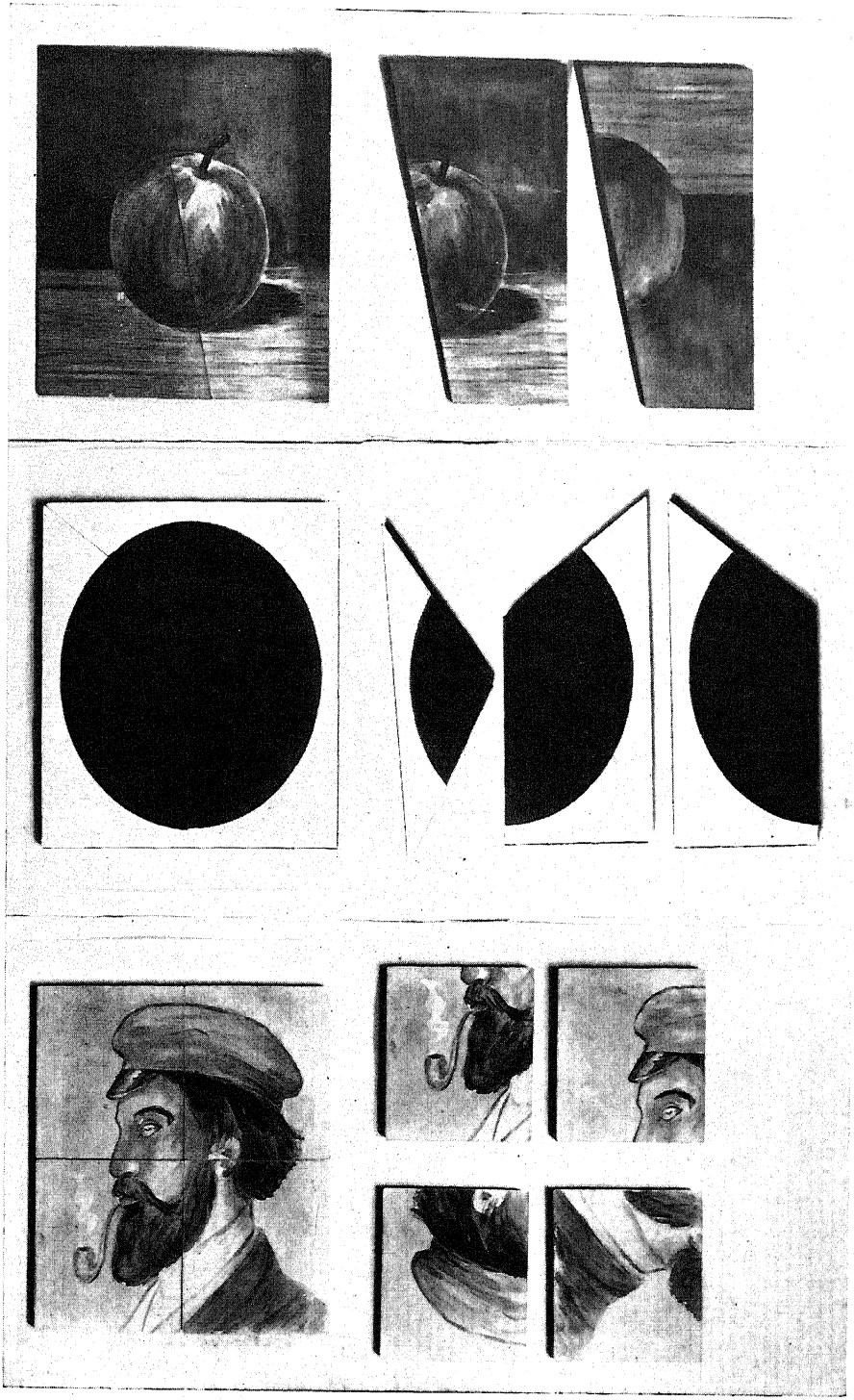

FIG. 24. ROSSOLIMO DISSECTED PICTURES, ONE TO THREE.

a picture." The record of time was kept with stop watch. Three minutes was the time limit for each picture. If two successive failures were made, the test was stopped. The actual time required for each picture was recorded. The score is the number designating the place in the series of the final picture which is correctly solved within the limits of the experiment. If picture five was completed within the three-minute limit, but neither six nor seven was solved, the test was stopped and the score of five was given. If a failure was made on six, then seven and eight were correctly solved, but failures were recorded for nine and ten, the score given was eight. In a few cases a child was permitted to try other pictures after two failures, but in no case was the attempt successful.

The scores given in Table XLIII show definite age differentiation in performance by intervals of six months. The difference is more apparent where the groupings are in intervals of a year. The coefficient of correlation for scores with chronological age is $0.79 \pm .01$. The regression is curvilinear and the correlation-ratio is $0.85 \pm .01$. The age difference is greater in the early years. This difference is more striking for the successive tests of the same children as given in Table XLIV. Those children who were first tested at three, four, or five years of age make approximately the same scores four years later as the children who were first tested at six, seven, or eight years of age make three or four years later. The older children make better initial scores but gain less on successive tests than the younger children do. This is true in some cases that could not be explained by the limitation of the test series. It appears that the school environment for these children has influenced the mental growth so that the young child who enters school at three or four years of age progresses more rapidly in ability to recognize details of stimulus patterns than does the child who is not subjected to this environment until he is six years old. The average time required for the test is necessarily longer, the greater the number of pictures completed. If these average times are related to the score made, it is evident that the average time required for a given picture decreases with increasing age.

An age difference not indicated by the scores is the tendency of the young child to be satisfied with an arrangement which is incorrect. Between the ages of three and five, the minor details of the design seem to be disregarded and some outstanding fea-

Table XLIII

ROSSOLIMO DISSECTED PICTURES, SCORE

Age	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	
Score																							
0	2	2	.....	2																			
1	.....	5	3	8	.....	1																	
2	.....	1	7	7	4	4	.....	.....	3	.....	1												
3	.....	1	3	10	8	6	5	2	3	1													
4	.....	1	.....	10	3	8	6	.....	11	4	1	.....	1										
5	.....	.....	2	1	2	6	7	4	15	6	1	1	.....	1	.....	.....	1						
6	.....	.....	.....	1	4	4	8	8	20	8	3	2	1	1	3	4	3	.....	.....	.....	.....	1	
7	.....	.....	.....	.....	2	3	8	16	16	9	4	8	7	3	2	8	7	1	.....	.....	1		
8	.....	.....	.....	.....	.....	4	3	9	5	16	9	7	3	8	6	3	8	1					
9	.....	.....	.....	.....	.....	.....	.....	.....	3	5	7	6	6	6	6	4	7	5	2				
10	.....	.....	.....	.....	.....	.....	.....	.....	1	1	.....	.....	1	1	3	3	3	1	2				
Total	2	10	15	39	23	36	37	39	77	50	26	24	19	20	20	22	29	8	4	.....	1	1	=502
Average Score	0	1.4	2.4	2.6	4.0	4.6	5.5	6.6	5.8	6.9	7.4	7.6	7.7	8.0	8.2	7.7	7.9	8.8	9.5	.....	7.0	6.0	
Standard Deviation	.....	1.2	1.2	1.4	1.6	1.9	1.5	1.2	1.7	1.6	1.7	1.0	1.4	1.1	1.3	1.3	1.3	0.8	0.5				

ture of the colored pictorial representation is the cue for the naming of the design. This name is frequently correct but a disconnected arrangement seems satisfactory as representing the named object. The older child may fail in the solution after naming the design to be constructed but is more critical of his arrangement, realizing that he has failed.

The following quotations from subjects support these observations. For picture III, a man smoking, many subjects said, "A man" before a minute had been spent in placing, but finally failed to make correct arrangement. One five-year-old boy said, "A man with a hump on his back." A four-year-old, after fifty-two seconds, said "Is he smoking a pipe? Yes, it's Daddy." Twice he suggested satisfaction with an incorrect arrangement but when told to look at it carefully continued to work and at two minutes twenty-one seconds had a correct placing. Another four-year-old had the four square pieces arranged in a horizontal row but said "A man." Other expressions were "Got an old man"; "This is a man, ain't it?" These failed to make a final correct arrangement.

For picture V there was again a quick response of "A house." In some cases it was finally completed; in others, there was a failure to make a final correct arrangement. One little girl said, "A house, but there's no fit to it. Seems to be two houses."

Picture VI, the oval, done in black, was called by one a dish; by another, a ball. A six-year-old boy said, "I don't know what it is; never saw a black egg. Don't look like a ball to me." A four-year-old girl said, "Looks like a broken vase." A boy seven years old called it a broken vase. One child had a semblance of a flower pot with large card as base, which seemed to please her much.

For picture VIII, the snake, done in black and gray, one seven-year-old girl said, "This is giddy," while a boy of the same age said, when the first cards were placed, "This makes you sick—a snake." Both of these failed to get a correct final arrangement but recognized the failure. A four-year old called it "steel rails."

For pictures II and IV, the circle and square done in black, such expressions as, "That is a record for Victro," "This is a picture frame," or "Roof of a house," "Oh, that's black again! I hate black!" indicated the interpretations that the young child

Table XLIV

ROSSOLIMO DISSECTED PICTURES

DISTRIBUTION OF SCORES AT DIFFERENT AGES FOR INDIVIDUALS HAVING THREE OR MORE TESTS

Score	0	1	2	3	4	5	6	7	8	9	10	Number of Cases	Average Score	Average Number of Scores	Average Interval Years
First Test															
At Three															
1st test	1	2	4	2	0	1	..	..	..	..	..	10	2.1	22.4	1.13
2d test	1	0	1	1	3	1	2	1	..	..	..	10	4.1	31.6	1.22
3d test	..	..	..	..	1	1	2	1	3	2	..	10	7.0	30.2	0.86
4th test	..	..	..	..	..	..	..	..	1	2	..	3	8.7	37.4	
At Four															
1st test	..	4	1	9	4	0	1	..	..	..	..	19	2.9	21.5	1.52
2d test	..	1	1	0	3	4	2	5	3	..	..	19	5.6	47.1	1.17
3d test	..	..	1	0	1	2	3	1	9	2	..	19	6.9	40.8	0.98
4th test	..	..	..	..	..	..	..	..	1	3	4	1	9	8.6	51.1
At Five															
1st test	..	..	..	2	2	1	3	1	1	..	..	10	5.2	45.2	1.35
2d test	..	..	1	0	0	1	3	2	2	0	1	10	6.5	35.3	1.11
3d test	..	..	..	..	..	..	..	..	3	5	2	..	10	7.9	43.4	0.90
4th test	..	..	..	..	..	..	..	..	..	..	1	..	1	9.0	55.6	
At Six															
1st test	..	..	..	..	..	2	3	8	..	..	..	13	6.5	38.3	1.54
2d test	..	..	..	..	..	..	2	3	4	3	1	13	7.8	51.2	1.00
3d test	..	..	..	..	..	..	1	1	5	5	1	13	8.3	55.9	0.85
4th test	..	..	..	..	..	..	..	..	1	0	1	2	9.0	54.7	
At Seven															
1st test	..	..	..	..	1	0	0	1	1	1	1	5	7.6	45.4	1.46
2d test	..	..	..	..	..	..	1	1	0	1	2	5	8.2	32.4	0.78
3d test	..	..	..	..	..	..	..	..	1	3	1	5	8.5	44.5	0.90
4th test	..	..	..	..	..	..	..	..	..	2	..	2	9.0	35.0	
At Eight															
1st test	..	..	..	..	..	..	..	..	1	1	..	2	8.5	34.7	0.65
2d test	..	..	..	..	..	..	..	..	2	..	..	2	8.0	62.0	1.05
3d test	..	..	..	..	..	..	..	..	..	1	1	2	9.5	59.5	
4th test	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
At Nine															
1st test	..	..	..	..	..	..	..	..	1	1	..	2	8.5	29.3	0.75
2d test	..	..	..	..	..	..	..	..	..	1	1	2	9.5	70.7	0.80
3d test	..	..	..	..	..	..	..	..	..	1	1	2	9.5	51.8	
4th test	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
At Ten															
1st test	..	..	..	..	..	..	..	..	1	2	..	3	8.7	39.5	0.97
2d test	..	..	..	..	..	..	..	..	..	3	..	3	9.0	47.1	

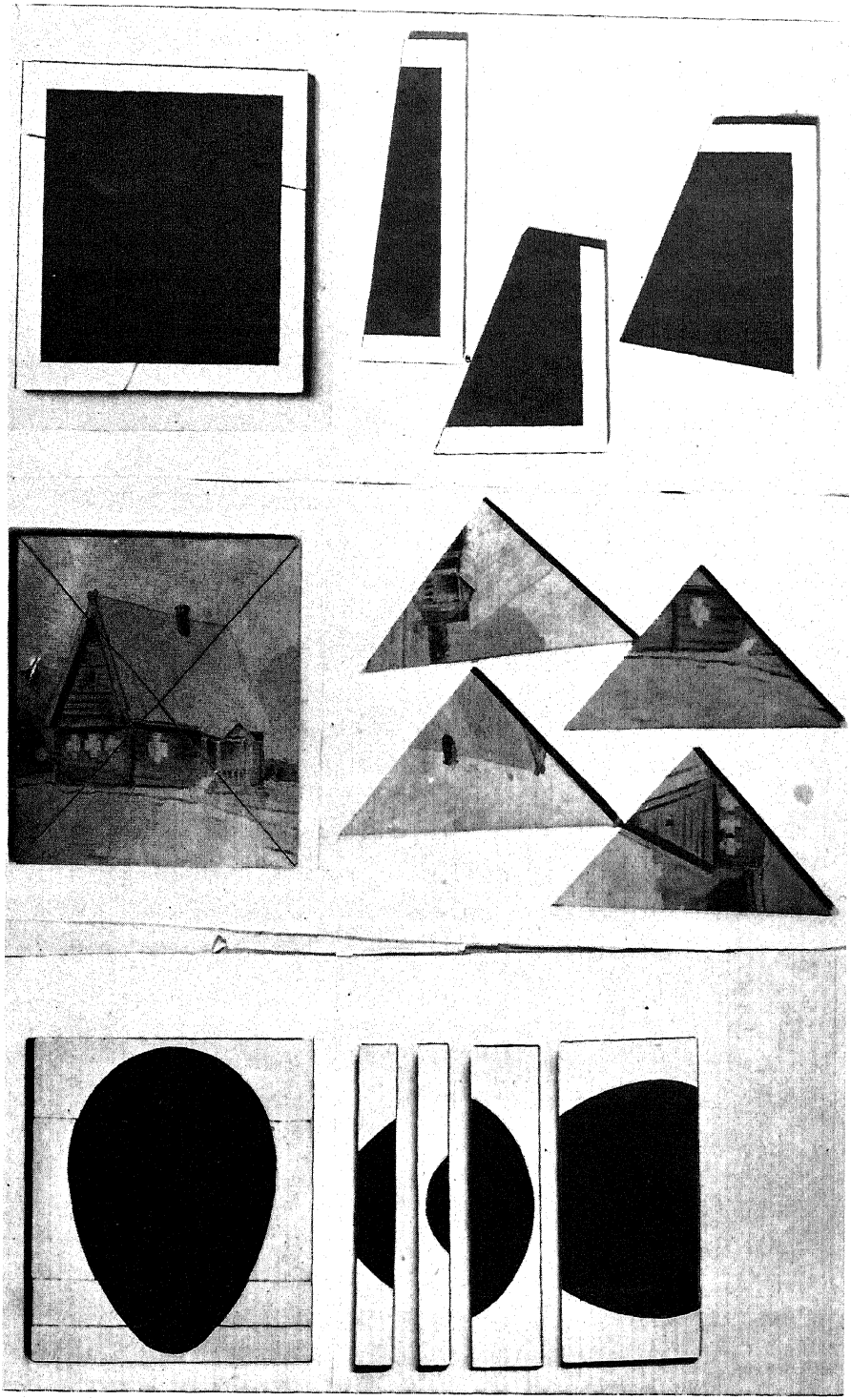

FIG. 25. ROSSOLIMO DISSECTED PICTURES, FOUR TO SIX.

makes. Some seemed to note the form, disregarding the color as for V, a house, dissected into four isosceles triangles, one child said "stairs," and with a final incorrect arrangement said again "stairs."

The pieces of picture X were put together and said to make four boats.

Various methods of attack were observed. Some seemed to note the form of the pieces and to attempt in a rational way to fit them, ignoring the design. Others appeared to decide from some outstanding feature what the object to be represented was, and worked toward this goal. This latter group has several divisions. One is satisfied with the solution correct as to the more prominent features but incorrect in minor details; another sets up a false goal, as in the case of the black and white studies, and finds his construction satisfying; while a third division notes the colors and attempts to match them.

The chance method is often used. Several pieces are placed before any idea is formed of the object to be represented. And again a solution hit upon by chance is perceived as a definite representation and is held satisfactory. This was especially evident with the vase-like arrangements for the oval in black.

The original arrangements of the black and white designs produced an irregular outline which in all correct constructions is a square. A frame into which the pieces could be fitted might throw light upon the tendencies to such arrangements, but would make a more suggestive procedure. It is significant that the young child attends to the form of the separate pieces and to the fitting of them together, rather than to the completion of a design; also that he does not tend to the forming of a square but makes rectangles and irregular forms as well as original designs. The greatest number of incorrect arrangements that were satisfactory to the child were made for the picture of a man smoking, while oval, snake, and house show a slightly smaller number.

The sex differences are not definite. At no age is the difference in average scores for sexes greater than 0.6 and the advantage sometimes lies with the girls, again with the boys. In general, the boys are slightly superior to the girls in score, and the girls have a slight advantage in the time required for a picture.

Order of Presentation

The procedure followed in our testing did not involve the testing of each child on each picture as the test was discontinued after two successive failures. It was possible, however, for a child to fail on one picture, succeed with the next, and then attempt other pictures in the series until two successive failures were made. Analysis of the percentage of successes out of the total number of attempts for a given picture was made for 111 cases. These are given in Table XLV. These results indicate that picture IV, the square, is easier than picture III, the man smoking; that VI, the oval, is easier than V, the house; and VIII, the snake, is more difficult than IX, the landscape. Since the young children were more frequently satisfied with constructions that were not correct, a time limit prevented the persistence

Table XLV

PERCENTAGE OF FAILURES IN ROSSOLIMO PICTURES

Picture.....	1	2	3	4	5	6	7	8	9	10
Attempts.....	111	111	111	111	108	105	93	64	27	12
Failures.....	0	2	30	9	43	26	62	57	21	12
Per cent failing.	0	1.8	27.0	8.1	39.8	24.7	66.6	89.0	77.7	100
Wrong solution accepted as correct.....	0	7	34	6	25	30	14	28	0	2

until a correct arrangement was made and all children did not attempt all pictures. Without a different testing procedure, the order of presentation can not be determined by the analysis for this small group.

Reliability

The coefficients of correlation for scores made in successive tests with the Rossolimo Dissected Pictures Series show that the test is a fairly stable measure for the ages studied. There were ninety-four children who were retested in two successive academic years, the interval between tests ranging from seven to seventeen months. For this group the coefficient of correlation for the two test scores was $0.78 \pm .02$. For a smaller group of

sixty-one children who were tested in three successive academic years, the coefficients of correlation were as follows:

Test I and Test II $r = 0.73 \pm .04$
Test II and Test III $r = 0.69 \pm .04$

The regression is practically linear with only a few outstanding cases.

Relation to Other Tests

The coefficient of correlation obtained for the Rossolimo scores of 301 children and their mental age at the time that the Rossolimo test was given is $0.81 \pm .01$. The regression is not linear (Blakeman's criterion, 3.83). The correlation-ratio is $0.866 \pm .01$ which shows a closer relationship than is indicated by the correlation coefficient. As was previously mentioned, the coefficient of correlation with chronological age is high (0.79), and correlation between mental age and chronological age is high (0.95). By partial correlations we find that the correlation-coefficient for Rossolimo score and mental age, with chronological age as a constant, is 0.31. The correlation-coefficient for Rossolimo score and median age rating by the Pintner and Paterson Scale of Performance tests is 0.853. This is slightly higher than that found with any other test. A more analytic study of the relationship between the various forms and designs entering into the separate tests in each series might lead to the development of a series that would be more efficient in a brief examination period than either single series.

Influence of Environmental Factors

The Rossolimo Picture Series is applicable to children of varying nationalities, social status, and school environments. Comparative ratings are given for the following groups in Table XLVI.

(a) Children in the City and Country school, primarily of American parentage, for whom social data are given in the introductory chapter.

(b) A Kindergarten class in a New York grammar school, conducted under the supervision of Mrs. Marietta Johnson, as an experimental approach to the reformation of Kindergarten methods in public schools.

(c) A regular first grade in the same grammar school. Some of these children had been in the Kindergarten class the preced-

Table XLVI

DISTRIBUTION OF ROSSOLIMO SCORES FOR DIFFERENT SCHOOL GROUPS

Picture Score.	1	2	3	4	5	6	7	8	9	10	Average	Total Number of Subjects	Range of Age in Months
Group													
Private School.	2	4	8	5	7	8	10	5	2	1	5.71	52	48–114
Kindergarten..	...	2	1	7	7	12	3	....	1	...	5.21	33	67– 88
First Grade...	...	1	3	9	13	6	8	3	1	...	5.38	44	74–108
Fifth Grade...	...	...	....	....	5	16	28	12	5	...	6.91	66	120–168
Total.....	2	7	12	21	32	42	49	20	9	1	5.9	195	

ing year; some failed of promotion to the second grade and were kept in the first grade; others were chance entrants from among the number of first grade entrants into the grammar school. Both groups (b) and (c) were composed almost wholly of Italian children born in this country but from homes in which Italian is the language spoken.

(d) The fifth grade group was composed of boys from three sections of the fifth grade of a public school in another section of New York City. A large percentage of this group were Hebrews of Russian or Austrian parentage.

The distribution of scores and the average scores for each group show no differences that would not be expected from the differences in chronological age and in mental age ratings, and indicate that the test is equally applicable to such groups.

Summary

The Rossolimo Dissected Picture Series shows definite age differentiation for ages three to nine with a greater difference in the early years.

Retests of children grouped according to the chronological age at the first testing show that the older children make better initial scores, but the younger children gain more in successive tests.

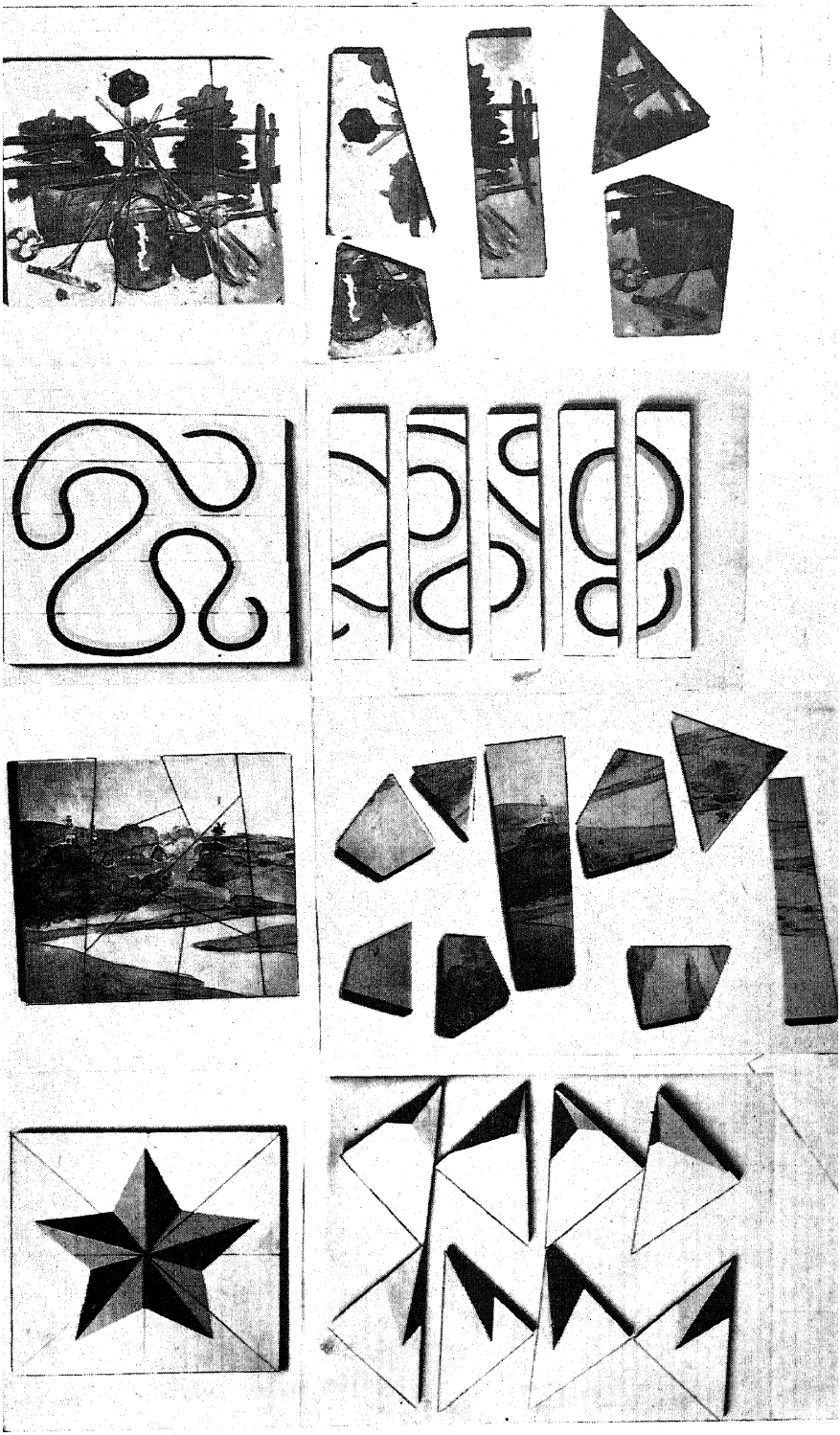

FIG. 26. ROSSOLIMO DISSECTED PICTURES, SEVEN TO TEN.

The coefficient of reliability (.78) shows that the test is a fairly stable measure for the ages studied.

There is a close correlation with mental age as determined by the Stanford Revision Scale and by the Performance Scale. Since all three measures show a good age progression, the factor of chronological age accounts to a large extent for the high coefficients obtained. When this factor is eliminated, there is still an indication that other things being equal, the child of a higher mental age rating will make the better score with the Rossolimo Pictures.

CHAPTER VI

SPECIFIC TESTS OF PERCEPTUAL AND THOUGHT PROCESSES

THE tests for which data are reported in this chapter are those which seem to measure certain mental processes which are not necessarily measured by the combinations of tests discussed in the preceding chapters. Some of these tests are especially desirable for the study of young children; others are better adapted to the differentiation of mental abilities of the older children.

These tests were added to the series of consecutive measurements in the endeavor to secure measures that would better differentiate the abilities of the children at the extremes of childhood. Sufficient data from re-examinations of the same children have not yet been obtained for tracing the rate of mental growth as measured by these specific tests. By the generalized method of obtaining average scores for different groups of children at different ages we have sufficient data to indicate the value of the tests for certain ages. It seems highly desirable that certain of these tests should be used in supplementation of the graded series for accurate analysis of changes in the mental abilities of children.

Two forms of measurements (Spot Counting and Location Memory), for which data are here given, illustrate methods that may be employed in making analytic studies of specific phases of mental growth.

THE WITMER CYLINDER TEST

The apparatus for the cylinder test, as described by Paschal (15), is a circular board having a series of recesses about its outer edge into which are fitted eighteen cylinders of varying dimensions. There is a central compartment in which all the cylinders may be placed.

Each subject was tested individually. He was seated at a table directly in front of the board. The board with the cylin-

ders in correct position was placed on the table with the largest cylinder at the point farthest from the child. The cylinders were removed from their recesses by the experimenter and were placed in the central compartment of the board. While doing this, the experimenter said, "I am going to put these blocks in the center and I want you to put them back where they belong. You may use one hand or both, and work just as fast as you can." In the study of the individual children, the child was allowed to continue if he gave evidence of ability to complete the test within a reasonable time, but comparative ratings are based on the first five minutes. The data reported show that eight minutes were required by some for completion of the test.

The test seemed an excellent one for the differentiation of the abilities of the children. Certain defects which appeared in the board made it impossible to get satisfactory results in the later testing program. A part of the board is formed of layers of pine glued together; the warping or chipping away of portions of these layers interferes with the fit of the cylinders into the recesses. We were not able to get a satisfactory board for the continuation of this test.

In Table XLVII it is shown that there is no constant decrease in time required by each age group within six-month intervals. The variability in each small group causes fluctuations in average scores. There is a definite tendency, however, for the time required to decrease with increasing age until the age of eight, after which the differences shown seem primarily due to the individual variability of small groups.

Paschal (15) found the decrease in time with increase in age in his study of performances in this test from age six to adults. He used the time limit of four minutes and the time for the shortest of three trials was the score used for his age standards. This is not directly comparable with our data since we gave only one trial. There were a number of failures for ages six to nine with that time limit. The median score for his group and the number of failures are appended to our data given in Table XLVII. Ide (10) tested 368 children at the age of five, and only 28 per cent succeeded. The time required by those who succeeded ranged from 60 to 120 seconds for 23 cases; from 120 to 240 seconds for 81 cases. Some of the children in our five-year group make a record of 61, but the work limit method permits of the long records above four minutes. The averages for the five-

Table XLVII

WITMER CYLINDER FORMBOARD, TIME

Age	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5
Seconds																
31- 60	.....	.....	.....	.....	.....	.....	.....	.....	2	2	1	.....	.....	3	3	1
61- 90	.....	.....	1	2	2	1	4	5	5	3	.....	3	5	7	5	1
91-120	.....	.....	1	3	2	4	7	12	8	2	1	.....	4	1	1	
121-	.....	.....	3	1	.....	3	5	8	2	3	.....	.....	.....	.....	1	1
151-	.....	1	3	.....	3	3	3	8	3	1	.....	.....	2			
181-	2	2	2	1	2	2	2	7	2	2						
211-	.....	.....	.....	.....	.....	2	4	5								
241-	.....	.....	2	2	1	.....	2	1	.....	.....	.....	.....	.....	1		
271-	2	.....	7	1	2	.....	1	2								
301-	2	.....	.....	.....	2	2	.....	.....	.....	1						
331-	.....	.....	.....	1	.....	.....	1	.....	1							
361-	.....	.....	.....	.....	.....	.....	2	..								
391-	.....	.....	.....	.....	.....	.....	.....	.....	.....	1						
421-	.....	.....	1	.....	.....	1	.....	1								
451-	.....	.....	.....	.....	.....	1										
Total	6	3	20	11	14	19	31	49	23	15	2	3	11	12	10	3=232
Average Time	260.5	180.3	223.7	179.5	197.6	200.9	175.6	162.7	125.0	145.0	79.0	80.7	104.1	86.4	76.9	93.3
Standard Deviation	50.7	11.9	84.2	90.5	68.4	111.3	85.8	67.8	60.5	92.9	26.0	9.3	32.7	50.9	25.2	43.4
Paschal-Median																
Boys	.....	.....	.....	.....	.....	.....	D. N. C.	.....	76	.....	63.5	.....	52.9	.....	49.8	
Girls	.....	.....	.....	.....	.....	.....	D. N. C.	.....	89	.....	68	.....	58.9	.....	50.5	

year group are within the limits given by Ide for those who succeeded.

The analysis of the successive scores from year to year for the same children was planned. The defect in the apparatus prevented that phase of the study. The satisfactory differentiation for ages three to six enhances the value of the test as a measure of abilities of the young child, for whom few desirable tests have been standardized.

The Dearborn Reconstruction Formboard, 1 C

This formboard is one of a series devised by Dearborn and Anderson and is illustrated by Dearborn, Christiansen, and Anderson (3). This particular form involves the shifting of some of the blocks already placed when the board is presented, and the use of certain extra blocks for filling all the depressions in the board. The procedure followed was that outlined by the authors mentioned. The child was told, "You are to fill up all the holes. You may change the blocks as you need to." Five minutes were set as the time limit. If the child was not successful within that time, but gave evidence of being able to complete the test, he was allowed to continue longer; otherwise the test was discontinued. Records of type of movement and of errors, as well as of time, were kept both of the complete and incomplete performances. This test was given only to the children between the ages of six and eleven.

The age progression shown for six months' intervals in Table XLVIII indicates the value of the test for age differentiation between the ages of six and eleven years. At six the number failing to complete the test exceeds by one the number who were successful. However, one six-year-old and two children in the six-and-a-half-year group make scores comparable with the best scores made at any age. In the higher age groups there are some who fail to complete the test. While the tendency is definite for the time required to complete the test to decrease with increasing age, there is wide individual variation at all ages.

A comparison with the scores obtained by Dearborn, Christiansen, and Anderson for small groups at the given ages is shown in Table XLIX. The scores for such small groups are subject to wide individual variations, hence the direct com-

Table XLVIII

DEARBORN FORMBOARD No. I C, TIME

Age	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	
Seconds																		
40–59	.....	.....	.....	.....	.....	.....	.....	.....	1	1	1	2	1	1				
60–79	.....	.....	.....	1	.....	.....	.....	2	1	1	2	.....	1					
80–99	.....	.....	1	1	1	.....	1	.....	2	2	4	4						
100–119	.....	.....	.....	1	1	2	7	1	1	5	5	2	3	1	.....	1		
120–	.....	1	.....	2	2	3	1	.....	2	.....	5	1	1	1	.....	.....	1	
140–	.....	.....	.....	.....	1	3	2	.....	.....	3	2	4						
160–	.....	.....	.....	.....	1	.....	.....	5	2	.....	1	4						
180–	.....	.....	.....	.....	3	3	.....	.....	1	2	2	3						
200–	.....	.....	.....	.....	2	2	3	.....	2	3	2	2	1					
220–	.....	.....	3	.....	1	4	1	1	4	1								
240–	.....	.....	.....	.....	.....	1	.....	1	1	.....	2							
260–	.....	.....	1	.....	1	.....	2	.....	.....	.....	.....	2						
280–	.....	.....	1	.....	.....	.....	1	1										
300–	.....	.....	1	.....	1	1	1	1	2	1	1							
320–	.....	.....	.....	2	1	.....	.....	2	.....	1	1	2	2					
340–	.....	.....	.....	2	.....	2	.....	.....	1	.....	.....	2						
360–	.....	.....	1	.....	.....	1	.....	1										
380–	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	1	.....	.....	1				
400–449	.....	.....	1	1	.....	.....	1	.....	.....	1								
450–499	.....	.....	.....	.....	1	.....	.....	1	.....	.....	2	.....	1					
500–549	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2						
550–599	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1							
D. N. C.	.....	.....	10	10	7	8	2	5	1	2	6	5						
Number Completing Test..	1	1	9	10	16	22	22	16	20	23	32	30	8	4	.....	1	1	=216
Average Time.....	586.0	125.0	273.7	231.1	208.4	205.1	201.7	233.1	185.1	167.9	187.6	199.4	155.9	173.3	.....	116.0	121	
Standard Deviation.....	.....	.....	93.5	127.2	97.3	75.2	102.3	115.8	81.7	82.3	127.3	121.2	122.0	163.3				

parison is only suggestive. For the youngest group the range of variation in scores for our group is wider with a consequent higher median score for time required than these authors obtained. The best performance of our group, however, is superior to that which they found. Our median score is slightly higher for the next age group, and our best score is again superior. For the oldest group they have a higher median score of time required, but excel both in the best score made and in time required for poorest performance. It is significant that so many failures are made in the group from eight to ten years of age.

Table XLIX

DEARBORN RECONSTRUCTION FORMBOARD I C

Age	5, 6 and 7		8, 9 and 10		11, 12 and 13	
		Dearborn		Dearborn		Dearborn
Number of cases	94	15	174	28	14	27
Median score	269	225	189	175	109	125
Quickest time	61	86	40	67	40	31
Slowest time	599	521	599	395*	461	334
Failures in 10 minutes	35	.....	21			

*One exception is reported without statement of actual time taken by this subject.

For study of the individual we need tests that differentiate the abilities within the small group, such as chronological age group, of which he is a member. This formboard test is of especial value for the ages nine to twelve of our group for which many of the other formboards give little differentiation.

Healy Completion Test No. II

A modified form of this test was used in the psychological examination given to the men in the army and is illustrated in the account of that work (13). The test as devised by Healy, requires a slightly different set of pictures and a still different procedure. We have followed Healy's procedure both in giving the test and in scoring. The instructions given to the child are as follows: "Here is a picture—it begins here where the boy is getting dressed. It shows the same boy, remember, doing one thing after another during the same day. You see in each pic-

ture a piece is missing. Here are a lot of small pieces, they fit in any of the spaces. But there are more pieces than you can use. The point is to pick out the piece that you think is needed, that is best to complete the sense of the picture. For instance, what is gone here? Yes, a shoe." If incorrect response is given say: "No, he is dressing and he is stooping for his other shoe. Now which is the shoe that he must have?" If incorrect one is selected, examiner says: "Yes, this one would not be right because he must have a high shoe to match the other one. Now, that is the way each is to be done. There is always some piece that is the very best one; you can tell which it is by studying the picture. Now go ahead." No help is given after this first explanation. Twenty minutes is the maximum time allowed for the test. The score given for this test is the sum of the score values for the different pieces that are used to complete the picture. If a piece is placed which is unrelated and would make an absurd picture, a minus score penalizes for such a performance. The total score that can be obtained is 100.

Table L

HEALY II, PICTURE COMPLETION TEST, SCORE

Age.....	4	5	6	7	8	9	10	11	12	13
Score										
−39 to 30	.....	.....	1							
−29 to 20	.....	.....	1							
−19 to 10	1	.....	4							
− 9 to 0	.....	1	1	.....	1					
+ 1 to 10	.....	.....	5	.....	2					
11 to 20	.....	.....	1	2	4	1	1	1		
21 to 30	.....	.....	1	1	11	7	3			
31 to 40	.....	.....	.....	.....	8	11	4			
41 to 50	.....	.....	.....	.....	4	8	4	2		
51 to 60	.....	.....	.....	.....	2	9	7	4		
61 to 70	.....	.....	.....	.....	1	3	2	2		
71 to 80	.....	.....	.....	.....	2	2	3	2	....	1
81 to 90	.....	.....	.....	.....	.....	.....	.....	1		
91 to 100										
Total.....	1	1	14	3	35	41	24	12	0	1=132
Average Score..	−12	−1	−2.7	17.3	32.9	43.5	47.6	58.3		
Standard Deviation....	.....	.....	15.4	5.9	17.7	14.3	16.8	17.9		

The scores for 132 children are given in Table L. The negative scores made by the children below seven indicate the difficulty of the test for the young child. They show the same tendency in this test that is shown in all the dissected picture tests—that of selection of piece for completion of the picture on the basis of some outstanding feature without regard for the complexities of the design or pattern that is to be completed. This differentiating feature with regard to age gives special value to the test, and the fact that negative scores are made by the six-year-old should not cause the elimination of the test from a series given to that age group, especially if a continuous study of the same children is in progress. There is definite improvement with age from six to eleven years. The variability within the age groups is approximately the same for those ages for which the number of subjects is sufficiently large for comparisons.

The Diamond Spot Series

The Spot Series used was one devised in the psychological laboratory of the Johns Hopkins University, using diamond-shaped spots instead of the usual round dots. This series was used to determine the ability to apprehend the number of objects shown, not to locate the components of the stimulus pattern. The patterns are shown in Figure 27. A lantern slide was made for each pattern. This slide could then be used in two different positions. However, the results reported were obtained from the use of the slides in one position as given in the illustration. A series of eight patterns (designated in Table LI by letters *a, b, c,* etc.) was first given in the following order of presentation with regard to the number of spots in a pattern: Series I, Number of spots: 4, 9, 7, 5, 10, 6, 8, 11. Two weeks later a second series (designated by numbers from 1 to 15 in Table LII) was given which included the same order of presentation for the first eight patterns and the repetition of certain patterns as follows: Series II, Number of spots; 4, 9, 7, 5, 10, 6, 8, 11, 7, 4, 6, 5, 10, 5, 7. The tests were given in the laboratory to a group of not more than fifteen children at one time. The children were seated at small tables at a distance of ten feet from the wall upon which the pattern was projected. The experimenter stood by the lantern at a distance of eight feet behind the children. Sheets of paper were given to each child upon which the letters or numbers

used to designate the patterns in order of presentation were written in a column. The instructions given were as follows: "When I say 'Ready, now' look at that spot on the wall and

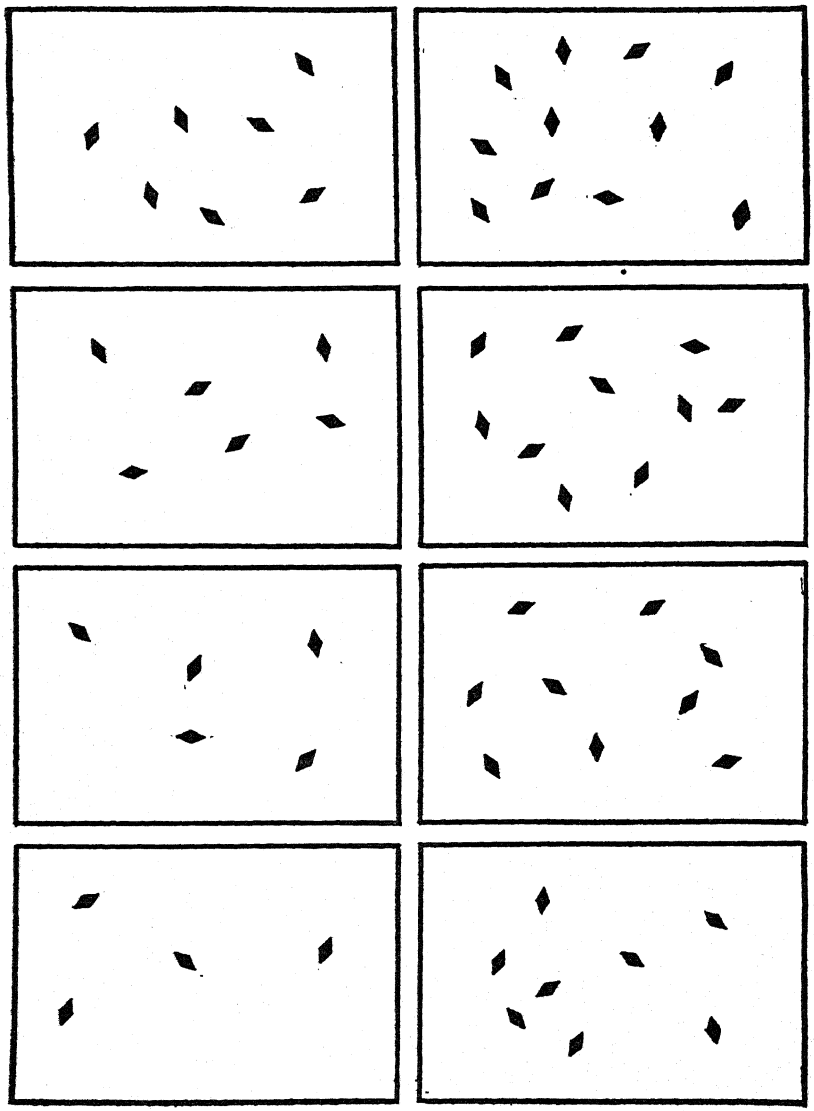

FIG. 27.—Diamond spot patterns.

keep looking at it until the picture is gone. Then write immediately the number of spots you saw. After the letter *a* (or number 1) write the number of spots for the first picture; after *b* (or number 2), the number of spots for the next picture." A sample slide was shown and the direction was given to look at

Table LI

DIAMOND SPOT SERIES

Key.....		4	9	7	5	10	6	8	11	Per Cent Correct	Total of Errors
Pattern.....		*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*		
Girls' Age											
2	8.3	4	9	8	5	11	6	8	11	75	2
8	9.4	4	13	8	5	10	7	9	11	50	7
9	9.7	4	8	7	5	10	6	8	12	75	2
10	9.8	4	7	6	5	9	.....	.....	.....	25	29
11	10.0	4	9	7	5	10	6	8	11	100	
12	10.1	4	9	7	5	10	6	9	11	87.5	1
13	10.3	4	8	7	5	11	6	10	12	50	5
14	10.4	4	10	7	5	10	6	9	11	75	2
15	10.6	5	9	8	5	13	.....	10	14	25	16
16	10.9	4	9	7	5	13	6	8	11	87.5	3
17	11.0	4	7	7	4	8	6	9	12	37.5	7
Per cent correct....		90.9	45.5	63.6	90.9	45.5	72.7	36.3	54.5		
Average error.....		0.09	1	0.36	0.09	1	1.18	1.45	1.54		
								Group average....		62.5	6.7
Boys' Age											
8	8.8	4	9	7	5	9	6	9	12	62.5	3
10	9.3	4	9	7	5	.....	6	8	.....	75	21
11	9.7	4	9	7	5	11	6	7	11	75	2
12	9.8	3	8	7	4	.....	6	8	12	37.5	14
13	9.9	4	9	7	5	11	6	7	11	75	2
14	10.2	4	9	7	5	10	6	8	11	100	
16	10.5	4	10	6	5	12	6	7	10	37.5	6
17	10.7	4	9	7	5	10	6	8	12	87.5	1
Per cent correct....		87.5	75	87.5	87.5	25	100	50	37.5		
Average error.....		0.13	0.25	0.13	0.13	3.13	.....	0.5	2		
								Group average....		67.5	6.13

that location on the wall for each picture. Children were cautioned not to write until slide was withdrawn. The time of exposure for each slide was three seconds.

Results for this test are given in Tables LI and LII. The order of difficulty determined by the number of spots in the pattern is not absolutely consistent. In the first presentation the order of difficulty as determined by the percentage of correct responses for each stimulus pattern is 4, 5, 6, 7, 9, 11, 8, and 10

Table LII

DIAMOND SPOT SERIES

Key		4	9	7	5	10	6	8	11	7	4	6	5	10	5	7	Per Cent Correct	Total of Errors
Pattern		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Girl's Age																		
1	7.8	4	9	7	5	10	6	8	11	7	4	6	5	10	5	7	100	
2	8.3																	
3	8.3	4	9	7	5	10	6	8	10	7	4	6	5	10	5	7	93.3	1
4	8.3																	
5	8.4	.....	9	7	5	10	6	8	11	7	4	6	5	10	5	7	93.3	4
6	8.5	4	8	6	5	10	6	10	12	10	4	6	5	12	5	8	53.3	11
7	8.8	4	9	7	5	10	6	8	11	7	4	6	5	10	5	7	100	
8	9.4																	
9	9.7																	
10	9.8	4	11	8	5	11	6	8	11	7	4	6	5	10	5	7	80	4
11	10.0																	
12	10.1	4	9	7	5	10	6	8	11	7	4	6	5	10	5	7	100	
13	10.3	4	9	7	5	10	6	8	11	7	4	6	5	10	5	7	100	
14	10.4	4	9	8	5	10	6	8	11	7	4	6	5	10	5	7	93.3	1
15	10.6																	
16	10.9																	
17	11.0	4	7	8	6	10	6	7	9	7	4	6	5	8	5	9	53.3	11
Percentage correct		90	70	60	90	90	100	80	70	90	100	100	100	80	100	80		
Average error		0.4	0.5	0.4	0.1	0.1	.....	0.3	0.4	0.3	.....	.....	.....	0.4	.....	0.3		
Group average		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	86.7	3.2
Boys' Age																		
1	7.6	4	9	7	5	10	6	8	11	7	4	6	5	10	5	7	100	
2	8.2	4	8	7	5	10	6	8	11	7	4	6	5	10	5	7	93.3	1
3	8.3	4	9	8	5	10	6	9	11	8	4	7	5	10	5	.....	66.7	11
4	8.3	4	9	7	5	10	6	8	10	7	4	6	5	10	5	7	93.3	1
5	8.4	4	9	7	5	10	6	8	11	7	4	6	5	10	5	7	100	
6	8.5	4	9	7	4	12	6	8	12	7	4	6	5	10	5	7	80	4
7	8.8	4	8	7	5	10	8	10	12	6	4	6	5	10	5	7	66.7	7
8	8.8																	
9	9.1	4	8	8	5	10	6	8	10	7	4	6	5	11	5	7	73.3	4
10	9.3																	
11	9.7																	
12	9.8																	
13	9.9	4	10	7	5	10	6	8	11	7	4	6	5	11	5	7	86.3	2
14	10.2	4	10	7	5	10	6	8	11	7	4	6	5	10	5	7	93.3	1
15	10.3	4	9	7	5	10	6	8	11	7	4	6	5	10	5	7	100	
16	10.5	4	9	7	5	10	7	8	11	7	4	6	5	9	5	7	86.3	2
17	10.7																	
Per cent correct		100	58.3	83.3	91.7	91.7	83.3	83.3	66.7	83.3	100	91.7	100	75	100	91.7		
Average error		.....	0.4	0.17	0.08	0.17	0.25	0.25	0.33	0.17	.....	0.08	.....	0.25	.....	0.58		
Group average		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	86.6	2.8

spots; in the second presentation this order becomes 4, 5, 6, 10, 8, 7, 9, and 11 spots. The repetition of certain of the stimulus patterns in the second presentation corroborates the order as to 4, 5, 6, and 7 spots, as given in the first presentation. The average error for each pattern was computed by averaging the differences between number of spots reported and the actual number of spots in the pattern. These average errors show greater difficulty in counting 8, 9, 10, and 11 spots, but the order within this grouping is not constant. If the omissions are disregarded there are no significant differences in average errors. The arrangement of spots with regard to favorable combinations might explain the lack of constancy in order of difficulty. It is highly important that an intensive study be made of the effect of the form of the pattern upon the accuracy of the perception of the child with varying times of exposure.

There are wide individual variations, the percentages of correct responses for first presentation, varying from 25 to 100 for girls; from 37½ to 100 for boys. In the second series, the percentages correct ranged from 53.3 to 100 for girls; from 66.7 to 100 for boys. The analysis of individual errors shows two tendencies. One individual never varies by more than one spot from the actual number presented in any of the stimulus patterns; others vary by two to four spots from the number given in one of the patterns, frequently making correct responses to the other patterns.

Age and sex differences could not be inferred from data for this small group, but the records given do not indicate greater ability at ten than at eight, nor a superiority of either sex.

There is a decided improvement in the second test both as to the accuracy of the report and as to the size of error.

The Location Memory Test

The Johns Hopkins Location Memory patterns and blank were used in this test which consists in reproducing a given pattern instead of merely reporting the number of spots seen. An illustration of the patterns is given in Figure 28. The patterns were presented by means of lantern slides, following the procedure outlined for the Diamond Spot Test. The instructions to the child were to make spots on his paper in those circles that would make his pattern look just like the one on the screen.

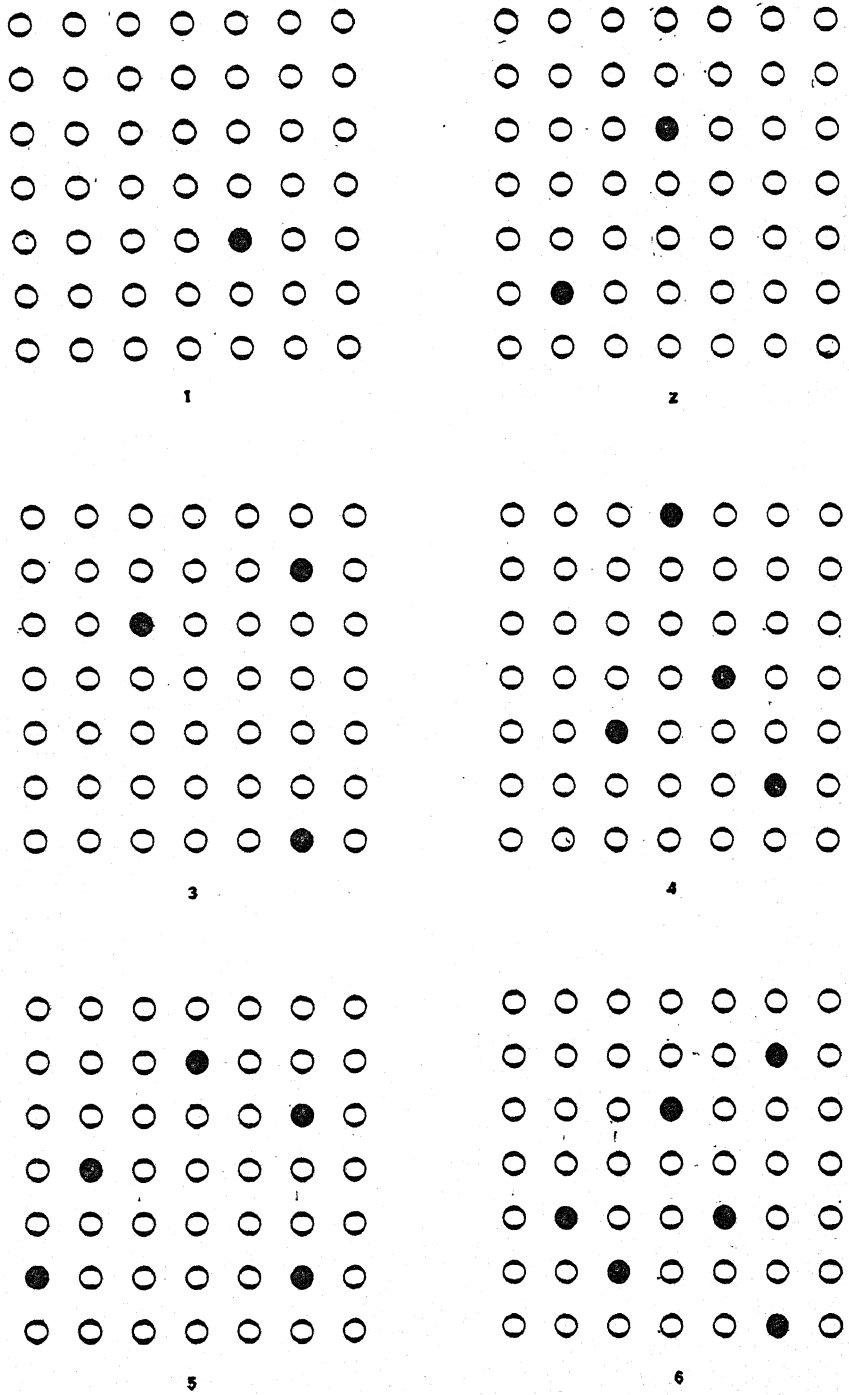

FIG. 28.—Location memory test patterns.

The first series consisted of six patterns, the number of spots ranging from one to six and presented in regular order. While the child was not told that there would be just one more spot each time, it seemed better to present them in that order so that adaptation to the test should be facilitated. The blanks were then collected, and this series was followed by Series II, in which the order of presentation as to number of spots in each pattern was: 1, 4, 3, 2, 5, and 6 spots. Two weeks later a third series was given with the following order of presentation: 5, 6, 2, 3, 4, and 1. Each slide was exposed for five seconds.

The results are given in Table LIII. No child succeeded in correctly reproducing more than two patterns, with the exception of one boy who had three patterns correct in Series III. The patterns given correctly were those having 1, 2, or 3 spots with the exception of the same boy who had a four-spot pattern correct in Series III. The total number of spots correct increased slightly with successive presentations, as shown by the average precentages of 30.8, 31.1, and 37.3 per cent correct for girls; 30.7, 36.3, and 39.3 per cent correct for boys for the respective series. The number of spots wrongly placed exceeds the number of omissions, indicating that the number was correctly perceived when definite form or location could not be reproduced.

The individuals vary widely as to number of spots correctly located out of the possible twenty-one spots. The range for girls is from two to eleven spots; for boys, from two to fourteen spots. There are no distinct sex differences shown for the groups although one boy is outstanding in his performance. The test seems very promising for individual differentiation and would probably show age differences if applied to a wider range of ages.

The Association Test: Opposites

The list of words used was List I given by Woodworth and Wells (28) consisting of the following words: long, soft, white, far, up, smooth, early, dead, hot, asleep, lost, wet, high, dirty, east, day, yes, wrong, empty, top. The following instructions were given to the child: "If I said tell me the opposite of good, what would you say?" If the child did not respond correctly he was told that *bad* was the correct answer as *bad* is as different from *good* as can be. He was then asked the opposite of *big*.

Table LIII

LOCATION MEMORY TEST, SCORE

Individual Cases Girls	Series Chronological Age	Patterns Correct	I Spots Total	Correct Per Cent	Spots Omitted	Patterns Correct	II Spots Total	Correct Per Cent	Spots Omitted	Patterns Correct	III Spots Total	Correct Per Cent	Spots Omitted
	Years												
1	8.3	0	5	23.8	3								
2	8.3	.....	.....	.....	.....	1 (1)	4	20	2				
3	8.4	.....	.....	.....	.....	0	4	20	13				
4	8.8	.....	.....	.....	.....	0	4	20	0				
5	9.4	0	3	14.3	7								
6	9.7	(1) 2 (2)	6	28.6	2								
7	9.8	1 (2)	11	52.4	6	1 (1)	8	40	6	(4) 2 (6)	10	47.6	3
8	10.0	1 (2)	6	28.6	3								
9	10.1	1 (1)	9	42.9	1	1 (1)	7	35	0	1 (6)	7	33.3	0
10	10.3	0 (0) (1)	6	28.6	9	(1) 2 (3) (1)	10	50	5	(3) 2 (6)	9	42.9	6
11	10.4	2 (3)	11	52.4	1	2 (3)	8	40	1	1 (6)	8	38.2	0
12	10.6	1 (1)	8	38.2	0	0	4	20	1	1 (6)	4	19.0	3
13	10.8	0	4	19.0	0								
14	11.0	0	2	9.5	0	1 (1)	7	35	2	1 (6)	9	42.9	1
Average.....	9.7	0.73	6.5	30.8	2.9	0.89	6.2	31.1	3.3	1.3	7.8	37.3	2.2
Boys													
1	7.6	.....	.....	.....	.....	0	8	40	4				
2	8.4	.....	.....	.....	.....	1 (1)	6	30	2				
3	8.5	.....	.....	.....	.....	0	6	30	5				
4	8.8	.....	.....	.....	.....	0	4	20	3				
5	8.8	0	2	9.5	5								
6	9.3	0	6	28.6	2								
7	9.7	(1) 2 (2)	14	66.7	0								
8	9.8	0	6	28.6	4								
9	9.9	(1) 2 (2) (1)	5	23.8	12	(1) 2 (3) (1)	10	50	3	(3) 2 (6) (3)	9	42.9	0
10	10.2	2 (3)	9	42.9	0	2 (4)	12	60	0	3 (5) (6)	13	61.9	1
11	10.3	0	4	19.0	1	0	4	20	6	0	4	19.0	1
12	10.5	1 (1)	8	38.2	0	1 (1)	8	40	1	1 (3)	7	33.3	0
13	10.7	1 (1)	4	19.0	8								
Average.....	9.4	0.89	6.4	30.7	3.6	0.75	7.3	36.3	3.0	1.5	8.3	39.3	0.5

Two examples were usually sufficient to elicit correct responses. Not more than 20 seconds was allowed for a given response.

The results given in Table LIV show an increasing efficiency in accuracy of response word and a shortening of the time required for a given response with increasing chronological age. The standard deviations indicate a marked clustering of the groups beyond the age of six, which suggests the addition of words offering greater difficulty for use over a wide range of ages and for a continued study.

Table LIV

ACTION AGENT TIME AND SCORE—LIST OF WORDS

Chronological Age in Years and Months	Number of Cases	Average Time, Seconds	Standard Deviation	Average Score	Standard Deviation	Number of D.N.C.s
yr. mo yr. mo.						
3 0 to 3 5	1	2.0	.....	12.0	.....	1
3 6 to 3 11	7	2.0	1.3	16.0	1.9	
4 0 to 4 5	28	2.8	1.4	16.7	3.2	1
4 6 to 4 11	27	2.4	0.8	16.7	2.9	
5 0 to 5 5	37	2.1	0.8	18.3	1.8	
5 6 to 5 11	40	2.1	0.9	18.5	1.9	
6 0 to 6 5	38	2.2	0.8	19.0	0.9	
6 6 to 6 11	25	2.0	1.2	19.4	1.0	
7 0 to 7 5	28	1.6	0.9	19.4	1.1	
7 6 to 7 11	19	1.5	0.9	19.7	0.8	
8 0 to 8 5	10	1.5	0.7	19.8	0.4	
8 6 to 8 11	10	1.2	0.5	19.6	0.5	
9 0 to 9 5	2	1.0	1.1	20.0	0	
9 6 to 9 11	2	1.5	1.9	20.0	0	
Total.....	274					

The list of harder opposites, beginning with *good* and given by Whipple (27) as List IV, which has been extensively used by other investigators, was given to twenty-nine children above the age of six. Twenty-four of this group were in the eight- and nine-year groups. The average scores made were 16 and 18 correct responses out of 20 possibilities. A standard deviation of 1.7 was found for each group. This list does not offer difficulty sufficient for clear differentiation of abilities at these ages. It is an experimental problem to determine a list of opposites that may be used in a testing program which involves the continued study of the same children throughout a period of years.

Since the opposites test plays such a large part in the combination tests used as General Intelligence Tests it is the more important that an analytic study should be made of age differences in this form of association.

The Association Test: Action Agent

The list of twenty words used was one given by Woodworth and Wells (28). The words of this list in order of presentation are: gallops, bites, boils, sleeps, floats, growls, sails, roars, scratches, stings, shoots, melts, swims, explodes, aches, blows, mews, cuts, flies, burns.

The instructions given the child were as follows: "Now I am going to say a word and I want you to tell me something that does, or can do, that thing. If I should say 'shines,' tell me what shines, 'howls' tell me what howls." If correct answers were not given, an explanation was made and the child was asked the same questions again. The response and the time for each individual response were recorded.

The time and accuracy scores for age groups at intervals of six months are given in Table LV. The time for a given re-

Table LV

ACTION AGENT, 20 WORDS

Differences in Scores in Retests of Fifty Children

	Number of Cases	Average Score	Average Time, Seconds
First test at three:			
1st test	2	18	1.8
2d test	2	18.5	1.3
3d test	2	20.0	0.8
First test at four:			
1st test	14	17.7	2.3
2d test	14	18.8	1.2
3d test	7	19.7	0.86
First test at five:			
1st test	17	18.3	1.7
2d test	17	19.4	1.6
3d test	9	19.4	1.2
First test at six:			
1st test	15	18.6	2
2d test	15	19.5	1.3
3d test	4	19.8	0.88
First test at seven			
1st test	2	20	2
2d test	2	20	1.8

sponse ranges from 2 to 2.8 seconds for ages three to six; from 1 to 1.6 seconds for ages seven to ten. The average scores and the standard deviations show that after the age of four there is but slight age differentiation, a large percentage of each group making the maximal score. The scores made in successive tests as given in Table LVI also show but little improvement with age

Table LVI

DIFFERENT RESPONSES IN THE ACTION-AGENT TEST

Age	3		4		5		6		7		8		9		Total	
Sex	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Number of Cases	6	6	27	20	34	41	35	26	32	18	12	10	2	4	148	125
Gallops																
Different	5	3	9	6	5	7	6	3	3	5	2	1	1	1	14	13
Percent different	83	50	33	30	15	17	17	12	9	28	17	10	50	25		
Failures	1	2	4	4	2	2	....	....	....	....	....	....	....	....	7	8
Bites																
Different	5	4	14	13	13	20	11	10	14	10	6	6	1	3	35	34
Percent different	83	67	52	65	39	49	31	38	44	56	50	60	50	75		
Failures	....	....	....	1	....	....	1	....	....	....	....	....	....	....	1	1
Scratches																
Different	6	4	18	10	16	15	10	7	8	7	4	3	1	1	35	24
Percent Different	0	67	67	50	47	37	29	27	25	39	33	30	50	25		
Failures	....	1	....	....	1	....	1	....	....	....	....	....	....	....	2	1
Growls																
Different	6	4	19	13	11	14	8	9	7	6	6	6	2	4	28	24
Percent different	0	67	70	65	32	34	23	35	22	33	50	60	0	0		
Failures	1	2	5	4	3	1	....	1	....	....	....	....	....	....	9	8
Stings																
Different	2	6	9	9	10	9	7	4	5	4	3	3	2	2	19	20
Percent different	33	0	33	45	29	22	19	15	16	22	25	30	0	50		
Failures	....	....	2	2	....	1	....	1	....	....	....	....	....	....	2	4
Blows																
Different	5	3	9	11	13	12	12	7	8	5	7	1	1	3	30	24
Percent different	83	50	33	55	38	29	34	27	25	28	58	10	50	75		
Failures	....	....	....	2	....	1	....	....	....	....	....	....	....	....	0	3
Burns																
Different	4	3	11	10	12	12	11	8	5	4	4	4	1	2	26	22
Percent different	67	50	41	50	35	29	31	31	16	22	33	40	50	50		
Failures	....	....	....	2	....	....	....	....	....	....	....	....	....	....	0	2
Cuts																
Different	5	4	9	8	10	11	11	6	7	5	5	2	2	2	27	19
Percent different	83	67	33	40	29	27	31	23	22	28	42	20	0	50		
Failures	....	....	....	2	1	....	....	....	....	....	....	....	....	....	1	2
Flies																
Different	4	4	13	5	10	10	12	8	11	6	3	3	2	2	23	16
Percent different	67	67	48	25	29	24	34	31	34	33	25	30	0	50		
Failures	....	....	....	1	....	....	1	....	2	....	....	....	....	....	3	1

after the age of four, which is apparently due to the high initial scores and consequent failure of the test to offer sufficient difficulty for age or practice differentiation. The average time for a response decreases with successive tests for all ages.

Nine of the words of this list were included in a shorter list which we first used and for which we do not report separate results since the complete list was soon substituted for the abbreviated list in the program of consecutive tests. Analysis of the responses for these nine stimulus words shows a significant age difference in the tendency toward greater frequency of common responses with increasing age. At ages three to five the percentage of individual responses exceeds on the average that for ages six and seven. These are given in Table LVII. The

Table LVII

SEX DIFFERENCES IN ACTION-AGENT TEST

Age	Girls			Boys		
	Number	Average Score	Average Time	Number	Average Score	Average Time
3	6	16.2	1.9	1	17	1.2
4	15	16.1	2.5	14	17.3	2.1
5	32	18.8	1.6	23	19.1	1.9
6	24	19.5	1.7	28	18.9	2.1
7	15	19.7	1.5	24	19.5	1.4
8	10	19.6	1.4	10	19.9	1.5
9	4	20	1.2	1	20	1.2
Total.....	106	.....	.....	101		

small number of cases at the extremes invalidate direct comparisons. The child under six, more frequently than the older child, substitutes that which is acted upon for the agent, the part for the whole, and a less common association which is correct for the commonplace response.

The wide range of response words and the frequency of common responses are evident from the following summary. The number after the word indicates the number of times out of the 274 responses that word was given for the particular stimulus word under which it is listed.

Gallops: horse, 213; modifications of horse, as horsie, horses, a horse, 30; other words given—ponies, horses feet, gee-gee, lion, animal, elephants, bull, cows, ostrich, people, girl, cowboy.

Bites: dog, 97; horse, 34; lion, 34; tiger, 24; snake, 11; animals, 7; other words given—mosquito, elephant, rabbit-wolf, shark, bear, rhinoceros, fox, kitten, cat, wolf, beaver, bulls, crocodile, donkey, mule, rat, puma, alligator, cow, camels, fly, fish, turtle snapping, frog, mouse, steam, teeth.

Scratches: cat, 157; modifications, as pussy-cat, kitty, kittens, 35; dogs, 12; tiger, 8; lion, 7; mouse or mice or rat, 6; other words given—squirrel, snake, bee, flies, bear, animal, hens, wolf, leopard, porcupine, animals, nail, hand, paws, finger nails, finger, pin, clothes, iron, anything.

Growls: lion, 81; bear, 54; dog, 39; tiger, 30; owl, 12; wolf, 10; other words given—animal, cow, horse, elephant, puppy, mouse, birdie, puma, baboon, cat, pigs, babies, bells, rain, man, a dress.

Stings: bee, 198; bees, 37; flies, 4; iodine, 3; butterfly, 2; other words given—cuts, train, kitty, man, engine, bug, wasp, juice, hornet, boats, kettle, mosquito, rooster, rats, pipe, darning needle.

Blows: wind, 194; horn, 12; whistle, 10; balloon, 9; air, 6; people, 3; mouth, 3; other words given—trees, boat, sails, umbrella, leaves, explosive, warship, outside, boy, airplane, fire, clothes, tongue, hats, flags, smoke, hair, paper.

Burns: fire, 170; wood, 34; stone, 14; paper, 11; food, 3; coal, 3; toast, 3; other words given—gas, house, supper, match, oatmeal, flames, meat, chocolate pudding, boiler, heat, steam, pot, kettle, soup, oven, iron, saw.

Cuts: knife, 180; knives, 7; scissors, 27; glass, 12; saw, 10; reaper, 5; other words given—sea-lion, shop, rake, cycle, people, men, dog, tiger, mower, tin, horses, birds, plow, cutting machine, teeth, barber, woodman, paper, knees, axe, sword, butcher.

Flies: bird, 129; butterfly, 54; fly, 52; bee, 11; other words given—wings, airplane, mosquito, plane, owl, cinders, dove, pigeon, bugs, fairy, boy, hornet.

The sex differences as shown by averages for age groups in Table LVIII are small and there is no constant superiority of either sex. This is true both of time and accuracy scores. The analysis of the response words also shows little sex difference. The percentage of individual words is, in general, approximately the same for boys and girls. At certain ages and for certain stimulus words there are fluctuations, but the trend is toward similar distributions of responses.

Table LVIII

EASY OPPOSITES (LONG) TIME AND SCORE

Chronological Age in Years and Months	Number of Cases	Average Time, Seconds	Standard Deviation	Average Score	Standard Deviation
yr. mo. to yr. mo.					
4 0 to 4 5	0				
4 6 to 4 11	1	2.1	.....	5.0	
5 0 to 5 5	6	2.6	1.0	14.0	3.2
5 6 to 5 11	5	2.3	0.7	15.20	3.9
6 0 to 6 5	10	1.8	0.7	16.90	1.7
6 6 to 6 11	17	2.1	1.0	17.00	2.9
7 0 to 7 5	22	2.2	1.1	17.91	1.5
7 6 to 7 11	14	1.3	0.5	18.64	1.3
8 0 to 8 5	12	1.7	0.7	18.00	1.9
8 6 to 8 11	11	1.0	0.3	18.64	1.7
9 0 to 9 5	2	1.2	0.1	20.0	0
9 6 to 9 11	2	2.9	1.9	19.0	0
10 0 to 10 5	1	0.9	.....	18.0	
10 6 to 10 11	0				
11 0 to 11 5	1	1.0	.....	18.0	
11 6 to 11 11	0				
12 0 to 12 5	0				
12 6 to 12 11	1	2.0	.....	14.0	
13 0 to 13 5					
Total.....	105				

The Ink-Blot Test

The material used was series 1–10 of the standardized ink-blots prepared by Whipple (27). Forty-five children from four to nine years of age were tested individually. The child was told that each card had a black spot or ink-blot on it and that he was to tell the first thing that he thought of after seeing the blot, or what the blot looked like. One card was presented at a time and the time elapsing from the presentation of the card to the first association given was recorded together with the verbal response. The procedure as planned involved only the record of the first thing suggested by a card; that card was then taken away and another presented. The verbal response, however, was frequently a phrase, sentence, or naming of several objects in quick succession, as is illustrated by the summary of responses.

A distribution of the average time required for a single verbal response is given in Table LIX for the different age groups. The time is considerably shorter in general than the averages reported by Pyle (18) which were obtained by a different method involving a written response and a time limit. The

Table LIX

PERCENTAGE OF DIFFERENT RESPONSES TO INK BLOTS

Age	Number of Cases	Range	Average
5	10	60–100	92
6	13	70–100	90.8
7	10	78–100	95.8
8	9	89–100	97.8
9	3	67–100	93.4

wider range of time scores shown for the six-year group does not seem significant of an age difference, as the number of cases in that group exceeds that for the other ages.

There is no significant age difference in the variety of responses made to a given blot, as each age group shows the marked tendency toward individual responses. The percentage of different responses for each age is shown in Table LX. Frequently there were as many responses as subjects. The greatest agreement shown in an age group was that of 40 per cent same answers given to Ink-Blot No. 3 by the five-year group.

A consideration of the agreement in associations for specific blots regardless of age shows a smaller percentage of individual responses. The following summary illustrates this agreement and also gives the types of associations.

Ink-Blot No. 1: Witch, 4; leaf, 3; Mother Goose, alligator, lady on horse, 2. The following responses, 1 each: a mother, girl, ladies, ladies' hair, woman and a baby, old woman in bed, lady with foot in shoe, lady on a branch, baby and mother on a horse, lady riding on a goose, girl sitting down with a bird, girl holding on to a baby, lady sitting down holding a branch, baby with no legs on a lady with torn dress, fairy with little child flying through air (feather in her hands), little girl with parrot in her hand on somebody's back, summer hat on a lady on a horse, little man in a——, man riding on another man, some leaves—— a man riding or a bear, people on a branch, bird, crab, crocodiles, a sort of dog, ant sitting on a crocodile, tree with bird, flowers, branch of a tree, top of tree, sky, map.

Ink-Blot No. 2: Man, 5; lady, 4; baby, girl, man sitting down, 3; old lady, little boy sitting down, pussy-cat, 2. The following responses 1 each: daddy, little boy, girl or boy, old man, part of a man, king, half a man, man (arms cut off), fat woman, girl lying down, lady sitting down, my little sister, two girls (with

Table LX

INK-BLOT TEST TIME

Average Number of Seconds per Picture	5th Year	6th Year	7th Year	8th Year	9th Year
1.0– 1.4 1.5– 1.9					
2.0– 2.4 2.5– 2.9	1	1 1		1	
3.0– 3.4 3.5– 3.9	2 2	2	1	1 1	
4.0– 4.4 4.5– 4.9	1			1 1	2
5.0– 5.4 5.5– 5.9	1	1 1	1 3	1 1	1
6.0– 6.4 6.5– 6.9	1	1	1	1 1	
7.0– 7.4 7.5– 7.9			2		
8.0– 8.4 8.5– 8.9					
9.0– 9.4 9.5– 9.9		1			
10.0–10.4 10.5–10.9			1		
12.0–12.4 12.5–12.9		1			
13.0–13.4 13.5–13.9		1			
14.0–14.4 14.5–14.9		1			
15.0–15.4 15.5–15.9		1			
16.0–16.4 16.5–16.9					
17.0–17.4 17.5–17.9					
18.0–18.4 18.5–18.9		1			

night gowns), negro with torn clothes, person sitting down, shoulders of somebody sitting down, baby with hair ruffled, dog, animal, moss, shadow.

Ink-Blot No. 3: Dog, 11; cat, 7; mouse, 3; squirrel, dog sitting down, 2. The following responses 1 each: dog on a slide, dog with boat in front, doggie with his tail behind, dog with shadow behind him, cat sitting down with his head looking at sun, rat, man, lady, finger, foot, nose, statue, slide, chair, bird, moon—full, map, pen with ink leaking out.

Ink-Blot, No. 4: Lobster, 4; man, 3; skeleton, fish, tree, tree with bird in it, 2. The following responses 1 each: crab, camel, bug, bird, bird with bait, lady and a fish, chinkie with a bird, something that crawls, Santa Claus, man with feet rolled up—no hands—ragged clothes, mouth, fingers, shoe, bag, hat, busted shoe, tar, sky, beehive, flying, bush, cloud, flowers, leaves, piano, fire engine, root or a train, paint dripping, path leading up to something.

Ink-Blot, No. 5: Butterfly, 6; camel, 2. The following responses 1 each: bear, lion, squirrel, a puppy dog, rat, spider web, rabbit and a pussy cat, dog with cap and eye glasses, birdie, two owls, two birds, chicken, baby, person, chair and a lady, old lady (colored), mother and father and baby—colored people, two men with a club, head, lungs, man's face, sky, sponge, rock, cloud, map, a mess, Ku Klux Klan, nothing, little lamp and a table, piece of a star, stone.

Ink-Blot, No. 6: lady, 10; man, 2. The following responses 1 each: Girl, girl (going out), old lady, angry old woman, funny lady, mother walking, colored lady with a bunny, lady with rabbit, woman with hat on, lady with umbrella and a dog, lady and her hat is breaking to pieces, colored lady with a bunny, girl all spattered up with mud, lady with her hat perched carrying a bag, people, man with skinny hands, a man with little child, man or old woman, but busted in two, big animal—pig and a little man, Charlie Chaplin, ears, bones—skeleton, bunny, dog, monkey, cat with a hat, pussy cat and a bunny, water, branch of tree, hill, shadow, I don't know, hat coming off.

Ink-Blot, No. 7: Crab, 2. The following responses 1 each: lobster, porcupine, rhinoceros, beetle, two saw fishes, horse running with a man, little dog jumping up on a boy backwards, chicken ruffling up her feather, hippopotamus, animal, thin man, old man, man on a pig, man's head, funny man, tree (a man climbing up it, roots), part of a fisherman's head, man riding on a lobster, man hiding behind a log, old man taking a root, old man with no legs—riding on animal, man riding an animal (a

fox), man's head sticking out of bushes, man with long neck—sticks on him, man with sticks coming out of him, man going to kiss a lady, Charlie Chaplin spilled something, lady, lady with a cat, Old Mother Goose, head, bones, tree, bag, branch, bush, root of a tree, shells (in the water).

Ink-Blot No. 8: The following responses 1 each: man, man upside down, policeman, part of a man, man standing on his head, Charlie Chaplin holding pistol, lady, a lady holding two cones, two hands, bones, ear inside, somebody with a broken head—an eye too, a part of someone—hands dripping with icicles, head, finger, bumblebee, reindeer, ostrich, animal, porcupine, two geese, horse's head, giraffe head, bird with two heads, bird's head, duck with two heads, crab with a head on, two birdies are singing, animal with horns, cat sitting on a tree, skeleton of calf's head, skeleton of horse's head, tree, bed, a lamp, pick-axe, design, stonewall, hat on a bowl, fireplace, top of pair of scales, piece hanging around her neck.

Ink-Blot No. 9: Animal, 3; tree, billy-goat, 2. The following responses 1 each: dog, bear, kangaroo, giraffe, duck, camel, cockatoo, turkey (except it has long ears), goat heads out of a rock, a big goose on top and bottom part a man, a bird with head down, man, skeleton, person with a wig, man standing on his head, trolley car man, man with sailor's hat, lady with more on one side than on the other, hammer, axe, feet, Indian, walking, hatchet, big rock, pick-axe, ghost, stone, candlestick burning, rocking chair, part of a globe, leaf on a tree, tree upside down, edge of a cliff—worn down gun.

Ink-Blot, No. 10: Hand, 4; man, man's hand, 3; snake, 2; 1 each: man with a candle, man stepping on a fish, Charlie Chaplin's hand, something on a man's head, man with funny thing, man with one long thumb, man coming out of a rock, funny man—crooked, man sideways with monk, man with fat hands—he is little—walking in the street, man's hand and face, body with arms sticking out, hand of a little boy with torn suit, lady with hand out, lady fighting, lady reaching out, grandmother, lady (with a long thumb), shoulder, animal, monkey, bird, chicken, rabbit, elephant, wild cat, fish standing up on a toad, buffalo's head (or a lion's), fire, tree (bent over) globe.

It is evident that humans and animals either in entirety, or in portions, predominate in the responses. If we total the different responses for each blot we find that 79.3 per cent are either

human or animal classifications. This is in agreement with the findings of Bartlett (2) and Parsons (14). The former found 59 per cent of 1068 suggestions were humans or animals; the latter found 54 per cent of responses for 97 children between seven and seven and one-half years of age were so classified. For certain blots there is fair agreement as to human or animal classification. For Blot No. 6, *woman* or *lady* was given in 63 per cent of the responses, for which Parsons found *woman* in 60 per cent of the responses; for blot No. 3 *dog* was given in 45 per cent of responses, and with qualifications, in 66⅔ per cent of responses. The number of different responses varies primarily within the limits of the general classifications. A comparison of the responses with those given by Whipple (27) as illustrative of adult responses shows little age differentiation as to general classification, but there are more modifications or qualifying phrases used by the children.

Summary

The Witmer Cylinders show satisfactory age differentiation, for our group from age three to age eight. It involves the discrimination of differences not usually tested in the young child and is suggested as of special value for the measurement of abilities at these ages.

The Dearborn Reconstruction Formboard and Healy Picture Completion Test II differentiate the abilities of the child at ages nine to twelve better than the majority of the specific tests in the performance scale. This characteristic indicates the value of these tests for supplementation of the performance scale and also for the measurement of special abilities.

The results for the Spot Counting Test and the Location Memory Test show that the experimental methods of the laboratory can be used with children for obtaining accurate data concerning the development of perception. Wide individual differences are shown. The ability to perceive the number of spots shown with a brief exposure and the ability to reproduce the stimulus pattern are decidedly inferior to such abilities in adults. There is a slight improvement with training. It is indicated that an analytic study of the accuracy of perception of the child is highly important.

The tests of association show an increase in speed and ac-

curacy with increasing chronological age until the limitation of the test series retards the progressive scores. The Action-agent form of association is more accurate at the early ages of childhood than the Opposites or association by contrast. There is a significant age difference in the percentage of individual responses given. For ages three to six the percentage exceeds that for the later ages. With increasing age there is a marked increase in the frequency of a given response, or in the number of commonplace responses as they are ordinarily termed.

In the Ink-Blot test there was no significant age difference shown in the variety of responses made to a single blot. The tendency was toward individual responses. The greatest agreement shown was 40 per cent same answers for one blot given by the five-year group. These different responses vary primarily within the limits of some general classification. Humans and animals predominate in the responses, forming more than three-fourths of the total number of responses given.

CHAPTER VII

CONCLUSIONS

MEASUREMENTS of mental growth and of certain related phases of organic growth repeated from early childhood at intervals approximating a year, show that in many traits the norms that have been established from single measurements of large groups are not satisfactory standards. Certain children vary from such standards by greater amounts than are held to be normal yet their rate of growth is similar to that of the so-called normal child. Different children grow at different rates, and the limitations of growth for an individual child set by hereditary tendencies influence the rate of growth, and therefore the stage of development of the child at a given chronological age.

Since bodily growth and growth in mental ability proceed simultaneously, there is an obvious relationship between the two in that growth of body is accompanied by growth of mind; but a recognition of this relationship does not explain the influence of one upon the other. Growth in height is closely correlated with chronological age. Weight is not quite so closely correlated with age, and the relative weight for height shows less correlation with chronological age. The lack of uniformity in growth in weight, with marked fluctuations occurring at various stages of development, makes the Weight-Height Index less stable as a standard for age differentiation. This index, however, is related to certain organic functions.

Blood pressure shows a tendency to increase less with increasing age than with an increasing ratio of weight to height. If we compute the relation between the blood pressure and Weight-Height ratio for a given chronological age, there is shown a tendency for the blood pressure to be higher in the individual who is relatively heavier for his height. This relationship persists in repeated measurements a year apart throughout the ages studied.

There is a tendency toward a greater decrease in pulse rate with increasing age than with an increased weight relative to the height. These relationships indicate the significance of the changes in organic functions with respect to each other.

Growth as determined by those measurements which are sometimes called physical, and again psycho-physical or mental, such as measurements of strength and of rate and precision of co-ordinated movements, also shows a close relationship to growth in bodily traits. The efficiency in such performances increases with age, but is also conditioned by the relative weight-for-height of an individual. This influence is greater when a greater amount of muscular effort is essential for success. It is not sufficient that we know that certain capacities of a child increase with age, but also that we learn what factors cause this growth. We find that such measurements are also related to the mental ability as determined by a series of tests such as the Binet-Simon Scale. The strength tests are less closely correlated with mental ability than are the more complex forms of muscular control. It seems that in such forms of measurement we are making a transition from the influence of mere structural changes of the organism to the measurements of reactions that are but little affected by such structural changes. This applies only to a group that would be classed as normal, and not to the pathological cases, in which there are probably structural defects in the nervous system.

The reliability of these tests of motor co-ordination, as determined by the maintenance of a position in the group by the same child in consecutive tests, shows that they are fair indices of specific abilities, and that they are useful both for age differentiation and for the determination of individual differences. It is also clear that the individual differences in such performances should be considered in relation to the same individual's structural development.

Those types of performance which involve little muscular effort but great accuracy of control seem but little dependent upon the weight and height of the individual or the relation between these two measures for the ages studied. This conclusion cannot be generalized at present because our group included few individuals of relatively high or low Weight-Height Index.

This lack of close correlation with bodily traits has also been found for the types of reactions generally classified as mental, in which the ideational elements predominate. Mental age as determined by the Stanford Revision of the Binet-Simon Scale increases with increasing chronological age and hence with increasing weight and height. The mental age of a group of the same chronological age does not show a significant relationship to the weight and height, to the absolute blood pressure, or to the pulse rate of the individual. Mental ability is probably more closely correlated with the amount of change in blood pressure and of pulse rate under varying forms of stimulation than with the absolute measurements.

This group of children in an experimental school which offers an enriched environment with regard to activities that may be undertaken, material that may be manipulated, and stimulation coming from social intercourse with others who are engaged in varied forms of activities, is with few exceptions, classified as superior at its first testing with the Stanford Revision of the Binet-Simon Scale. The average Intelligence Quotient for this group is seventeen points higher than the average for the public school children tested. Children from other private schools tested at these ages have a similar superior average rating by the Stanford Scale. It appears that young children of a social environment that would probably be classed as somewhat above the average have, in general, Intelligent Quotients that are above the norms commonly given for the same ages. There is, however, a tendency for the quotients to decrease with increasing chronological age; hence, either mental growth proceeds at a more rapid rate during the first four or five years than it does thereafter; or else the standard used for measuring mental growth is not adequate.

This decreasing tendency of the quotients is observed when different groups of different chronological ages are measured. When, however, a group of children are tested by the Stanford Scale at intervals throughout a period of years, there is lack of uniformity in mental growth so measured. Such children increase more rapidly in mental age than in chronological age at certain stages, and at other stages they show retardation in rate of mental growth. Other children show a more gradual increase or decrease in mental progress. We believe, therefore, that the

Stanford Revision of the Binet-Simon Scale is not adequate for the extremes: the scores for the young child especially are influenced by environmental training.

The scores made in the specific tests of the scale of performance tests show fair progression with increasing age. The varying combination of tests that may be used for determining the median age score by this scale does not give uniform progress. It is essential that other tests be added to this scale, some of which will be valuable for the study of the children below six, and others that will give better differentiation of abilities in the later years of childhood.

The age differences determined by successive tests of the same individuals are greater than those differences obtained from measurements of different groups of children at different ages. This suggests an influence of practice and also of the school environment, since the score made by these children exceeded the norms given for such tests. It is clear that tests which are to be combined into a graded series for use in the diagnosis of the mental development of the child should be analyzed with regard to these influencing factors and that the mental growth shown by consecutive measurements of the same child should be the standards of reference for an individual child. The group we have studied is not representative of children at large since we classified the group according to the two scales used by which they are decidedly superior in mental ability. For a thorough determination of the rate of mental growth by these tests, we need consecutive studies of larger groups variously selected.

The study of certain specific tests (Rossolimo Series, Witmer Cylinder, Dearborn Formboard, Healy Picture Completion II) shows a good age differentiation by these tests and that they are valuable for measurement of the mental ability of children above six years of age. The first two tests are also of value for the children below six years of age.

Other specific tests (Diamond Spot, Location Memory, Association) that seem to measure mental processes that are not involved in the other types of tests mentioned are practical for use with children and should be applied to larger groups for an understanding of development in mental abilities. Some of these specific tests give promise of satisfactory differentiation beyond the age of twelve.

The selection of a more extensive group of tests for combination into a diagnostic series is desirable. This broader series is needed especially for the continued study of the same individuals, since we must be interested in determining how the mental life of the child develops and not merely in making a gross estimate of his general status with regard to his age group.

REFERENCES

REFERENCES

1. BALDWIN, B. T.: Physical growth of children from birth to maturity. Univ. of Iowa Studies in Child Welfare. 1921. p. 411.
2. BARTLETT, F. C.: An experimental study of some problems of perceiving and imaging. Brit. J. Psychol. 1916. Vol. 8, pp. 222–267.
3. DEARBORN, W. F., CHRISTIANSEN, A. O., and ANDERSON, J. E.: Formboard and construction tests of mental ability. J. Educ. Psychol. 1916. Vol. 7, p. 449.
4. DEWEY, E., CHILD, E., and RUML, B.: Methods and results of testing school children. E. P. Dutton & Co. 1920.
5. DUNLAP, K.: Improved forms of steadiness tester and tapping plate. J. Exper. Psychol. 1921. Vol. 4, No. 6, pp. 430–433.
6. GARRISON, S. C.: Additional retests by means of the Stanford Revision of the Binet-Simon tests. J. Educ. Psychol. 1922. Vol. 13, pp. 307–312.
7. GUNDOBIN, N. P.: Die Besonderheiten des Kindersalters. Berlin. 1912.
8. HOLSOPPLE, J. Q.: Reliability of scores in steadiness tests. J. Exper. Psychol. 1922. Vol. 5, No. 3, pp. 203–213.
9. HUNT, Jean L., JOHNSON, B. J., and LINCOLN, Edith M.: Health education and the nutrition class. E. P. Dutton & Co. 1921.
10. IDE, G. G.: The Witmer formboard and cylinder as tests for children two to six years of age. Psychol. Clinic, 1918. Vol. 12, No. 3, p. 65.
11. JOHNSON, B. J.: Practice effects in a target test—a comparative study of groups varying in intelligence. Psychol. Rev. 1919. Vol. 26, pp. 300–316.
12. JOHNSON, B. J., and SCHRIEFER, Louise: A comparison of mental age scores obtained by performance tests and the Standard Revision of the Binet-Simon Scale. J. Educ. Psychol. 1922. Vol. 13, No. 7, pp. 408–418.
13. MEMOIRS: National Academy of Science. Vol. 15. 1921.
14. PARSONS, Cicely J.: Children's interpretations of ink-blots. Brit. J. Psychol. 1917. Vol. 9, pp. 74–92.
15. PASCHAL, F. C.: A report on the standardization of the Witmer cylinder test. Psychol. Clinic. 1918. pp. 54–59.
16. PINTNER, Rudolf, and PATERSON, Donald G.: A scale of performance tests. D. Appleton & Co. 1917.
17. PORTER, W. T.: Seasonal variation in the growth of Boston school children. Amer. J. Physiol. 1920. Vol. 52, pp. 121–131.
18. PYLE, W. H.: A manual of the mental and physical examinations of school children. Univ. of Mo. Bull. 1916. Vol. 17, No. 24, p. 32.
19. ROSSOLIMO, G.: Die psychologischen Profile. Klinik für psychische und nervöse Krankheiten. 1911. Vol. 6, p. 249.
20. SLADKOF: Der Blutdruck beim Kinde. Dissert. St. Petersburg. 1903.
21. SMEDLEY, F.: Report dept. child-study and pedagogic investigation; reprint from 46th Annual Report, Board of Educ. Chicago, 1899–1900.

22. STALNAKER, Elizabeth: A comparison of certain mental and physical measurements of school children and college students. J. Comp. Psychol. 1923. Vol. 3, pp. 181–239, 431–468.
23. STENQUIST, J. L.: Constancy of the Stanford-Binet IQ as shown by retests. J. Educ. Psychol. 1922. Vol. 13, pp. 54–56.
24. TERMAN, L. M.: The measurement of intelligence. Houghton Mifflin, 1916.
25. TROUSSEAU: Journ. conais. mediocochir. Reported by Gundobin.
26. VIERORDT, Karl: Physiol. d. Kindes. Gerhardt's Handbuch. 1881.
27. WHIPPLE, G. M.: Manual of mental and physical tests. Vols. I and II. Warwick & York, Inc. 1914.
28. WOODWORTH, R. S., and WELLS, F. L.: Association tests. Psychol. Monog. 1911. Vol. 13, No. 57, p. 58.
29. WOOLLEY, H. T., and FISCHER, C. R.: Mental measurements of working children. Psychol. Monog. 1914. Vol. 18, pp. 1–247.

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